FOR SPECIAL TRANSFORMERS

It is significant that, on the whole, difficult transformer jobs find their way to UTC. A few recent illustrations of accomplishment through engineering ingenuity are shown below.

This transformer was designed for laboratory apparatus requiring a frequency range previously unheard of . . . flat within 2 DB 2 cycles to 20,000 cycles, this unit handles 25 watts output.

A manufacturer had the problem of changing his equipment from 400 cycle to 60 cycle power supply, but discovered that 60 cycle transformers are twice as large. UTC developed a unit, hermetically sealed, that fit his existing chassis, eliminating the need for a complete rebuilding of the equipment.

Narrow band filters are a common requirement for multiple channel telecontrol purposes. To effect a maximum number of channels in the audio range, filters made by UTC employ toroid high Q coils of unique structure. A typical special filter with 1500 cycle pass band is down 40DB at 1400 and 1600 cycles.

Low power 115 volt appliances such as electric razors, fluorescent desk lamps, etc. are sometimes required to operate on 220 volts. For simplicity of installation in the application of one manufacturer, a 15 watt plug-in unit was developed incorporating both plug and receptacle.

The UTC engineering department is available for consultation on your design problem

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Let TINNERMAN *analyze your fastening problems*

BEFORE You Leave the "Mock-up" Stage

Just as the Galvin Manufacturing Corp. did with their new Motorola Auto Heater

★ **These 14 Fasteners did the Trick**

Our new Bulletin No. 214 goes into detail on this Motorola job and is available for the asking. Since you may be able to use to advantage many of the fastening ideas illustrated, write for a copy today.

To take full advantage of the SPEED NUT System of Fastening, Galvin engineers brought the "mock-up" and prints of their new Motorola Heater to Tinnerman for a fastening analysis *before* building tools and dies. They sat right in with Tinnerman development engineers who went over the heater part by part—explored every possible production short cut—planned its assembly from start to finish.

The final design of the heater was modified to take advantage of *standard* SPEED NUTS wherever possible. Where standards could not be used, new SPEED NUTS were created for a more efficient assembly. The result was *assembly perfection.* Many parts were attached with SPEED CLIPS and merely snapped into position under spring-tension. Others were fastened by simply pressing SPEED NUTS over unthreaded studs. And where it was necessary to use screws, SPEED NUTS made the attachments simple and fast.

This engineering service is available to you, too—at no cost. For the utmost in assembly savings, contact our Sales Engineering Department before you leave the "mock-up" stage. But in any event, check the SPEED NUT System of Fastening before you go into production.

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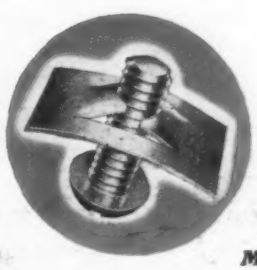
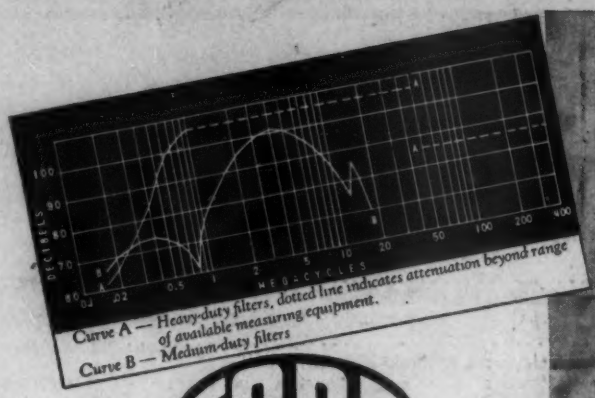
Speed* Nuts★ PATENTED



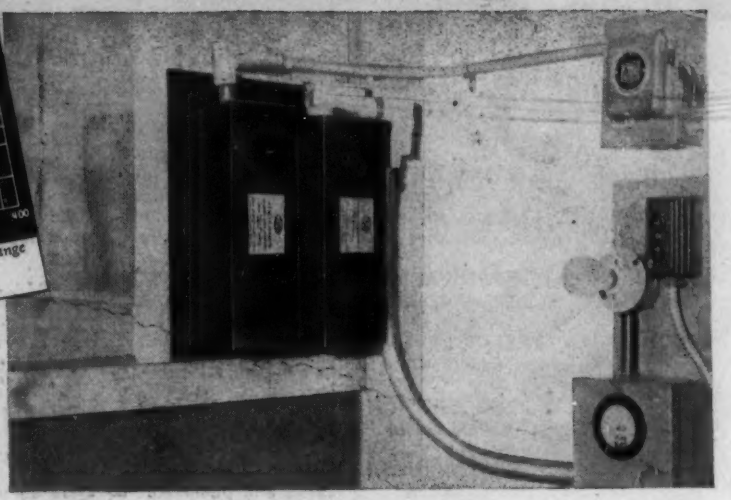
*Trade Mark Reg. U. S. Pat. Off.

FASTEST THING IN FASTENINGS ***MORE THAN 4000 SHAPES AND SIZES***

For RADIO·SILENT Test Rooms



Curve A — Heavy-duty filters, dotted line indicates attenuation beyond range of available measuring equipment.
Curve B — Medium-duty filters

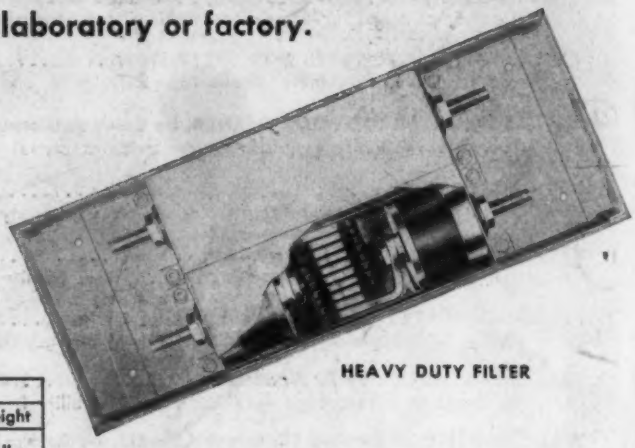


TOBE

Screen Booth Filters

isolate test rooms in laboratory or factory.

Installed where the electric power service passes through the screen, these Filterettes provide high attenuation from 150 kc to 400 mc, thus permitting operation of sensitive high-frequency test apparatus in close proximity to electric production equipment, welding generators, repulsion motors, and high-frequency induction heating equipment.



HEAVY DUTY FILTER

SPECIFICATIONS

HEAVY DUTY FILTERS					
Type	Amperes	Volts	Volt. Drop	Freq. Range	Weight
Two Wire	100	500 a-c/d-c	.2 volts per circuit	0.15 to 400 megacycles	40 lbs.
Three Wire	100	500 a-c/d-c	.2 volts per circuit	0.15 to 400 megacycles	65 lbs.
MEDIUM DUTY FILTERS (Two Wire)					
No. 1137	20	110/220 a-c 500 d-c	.5 volts per circuit	0.15 to 20 megacycles	17 lbs.
No. 1116	50	110/220 a-c 500 d-c	.5 volts per circuit	0.15 to 20 megacycles	17 lbs.

Widely used by government, college, and industrial laboratories, Tobe Screen Booth Filters will meet *your* need; Bulletin 472 E , free on request, gives additional data. For information about the complete line of Tobe Filterettes and Capacitors, ask for our general catalog.

Our specialists will advise on construction of screened test rooms and on filter installations.

Mechanical design and assembly conform to practical electrical installation requirements. Outer housings are of welded steel; knockouts at each end accommodate electrical conduits; heavy, threaded studs facilitate attachment of cable lugs.

These units employ non-inductive, mineral-oil impregnated capacitors; the inductors, of large cross section, have low series resistance, hence voltage drop is negligible. Overload ratings are: 150% of ampere rating for one hour; 200% of voltage rating for one minute.

Tobe Screen Booth Filters are standard for the electronics industry; there are sizes for every requirement.

TOBE

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Airline
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Experimental r-f

EIMAC 4-750A POWER TETRODE Electrical Characteristics	
Filament: Thoriated tungsten	
Voltage	7.5 volt
Current	20 amp
Direct Interelectrode capacitances (av.)	
Grid-plate	.24 μμf
Input	26.85 μμf
Output	7.78 μμf
Maximum Ratings	
D-C Plate Voltage	6000 max. volts
D-C Plate Current	700 max. ma.
Plate Dissipation	750 max. watts

Here's a new **Eimac tetrode**—the power step-up you have been asking to have added to the Eimac line.

Capable of 2-kw power output at 4000 plate volts, with less than 15 watts of grid drive, the 4-750A opens a new field of possibilities to designers of electronic equipment. A pair of these tetrodes, driven by low cost, low-power tubes, will supply more than 4-kw output.

A potential workhorse for communications and industrial use, the 4-750A has the ability to deliver its maximum power over a wide range of frequencies. Inherent characteristics include the familiar attributes of Eimac tetrodes—stability, economy, and dependability.

Complete technical data and performance characteristics will soon be available. Write now for your copy.

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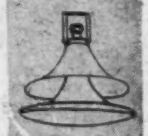
Many sizes. From 15 in. air column to 6 foot air column.



360 RADIAL, CHANDELIER PROJECTORS

Double Reentrant. For driver units. 3 and 4 foot air column lengths.

DRIVER UNITS

Various Power Handling Capacities. Newest types of Indestructible Phenolic Diaphragms.

MINIATURE TYPE REENTRANT PROJECTORS—

BOOSTER SPEAKERS.

High-efficiency, Weather-proof. Complete with Driver Unit and Universal Bracket.

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MICROPHONE SUPPORT STANDS

20 types and sizes. All Fittings, Adapters and Accessories. Floor Stands, Desk Stands, Banquet Stands, Room Stands.

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CORPORATION
1449 39th St., Brooklyn 18, N. Y.

BUSINESS BRIEFS

By W. W. MacDONALD

Marine Radio Equipment should be as hot as a stove this summer. Mixing business with pleasure (we have a subminiature auxiliary sloop out on Long Island Sound), we took in the boat show at New York's Grand Central Palace. At least a dozen manufacturers of ship-to-shore phones, d-f equipment, underwater sounding devices and other electronic navigational instruments exhibited and interest in their gear was running high.

Speaking Of The Palace, IRE'S ambitious exhibit there this month will just about fill two of the three available floors. Originally planned for a New York armory, the shindig quickly outgrew its quarters and is certain to be highly successful. It will not, however, be a sellout. A few potential exhibitors were discouraged by the higher-than-usual booth cost and the three-buck admission charge for non-members. (The Palace's take must be considerable.)

Selenium Rectifiers will replace notoriously short-lived 117-volt tubes in the majority of 3-way portables built this year. Chief engineers with whom we have talked in the past month say cooler operation and instant starting are distinct advantages in this type of receiver.

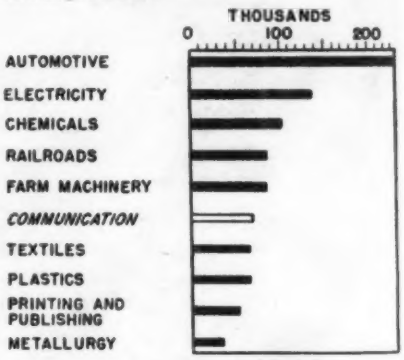
In other types of sets such rectifiers are not expected seriously to challenge the tube at this time despite the fact that they are smaller and deliver more output voltage. They will, however, be seen in a number of straight phonographs above the jitterbug-portable class, and in some ac-dc consolettes, consoles and even combinations designed for the medium-priced market.

Factors which at least temporarily limit the acceptance of the ingenious little discs, particularly for use in ac-dc table-type receivers, include the somewhat higher overall cost (when substituted for a tube in a 5-tube set a dropping resistor must be added to the heater string), the difficulty of handling pilot lights, and uncertainty about shelf-life.

A Three-Day Trip to New England convinces us that textile machinery manufacturers are progressive. Looms in particular do not lend themselves to electronic control as readily as do certain other machines but we did see some very practical laboratory applications of stroboscopes and high-speed cameras using the Edgerton principle. And an application of strain gages about which we can say no more at this writing.

Total Output Capacity of the 3,000-odd electronic induction and dielectric heating units in use in the United States in 1946 is estimated to be over 42,000 kw. These figures are from a NEMA brief recently filed with the FCC. The Association is planning a 1947 survey on the subject.

Patents issued to ten major industries up to November 1946 break down as shown in the following chart:



The National Patent Council, from whom the figures were obtained, says the Communication bar includes 22,750 patents for telephony, 14,491 for radio, 10,114 for telegraphy, and 408 for electric signalling.

Miniature Tubes will show up in more broadcast-band sets this year than a lot of people expect. It seems that while they cost a few pennies more than conventional types when socket cost is

are beginning to realize that while concentration on the half-dozen applications having top-drawer market acceptance may not be romantic the volume pays the rent.

Airplane Crashes have made the flying public jittery, even though few scheduled American flights are involved. Aviation's current headache may be a boon to electronics, speeding international acceptance of PICAO recommendations (p 80, Feb.). Members of Congress are exercising their vocal chords about other safety devices. And we note with satisfaction that a large airline has just bragged in the newspapers that soon all its ships will have radio altimeters.

1946 Receiver Production is estimated at 15,000,000 by RMA. The following tabulation does not add up to that because the Association's report service did not get into full swing until several months had elapsed but it does shed light on the relative importance of various receiver types:

TYPE	PRIVATE BRAND	FACTORY
Electric		
Table (under $12.50 billing price)	436,091	1,841,572
Table (over $12.50 billing price)		
AM	1,065,159	4,940,033
AM-FM		13,174
FM (including converters)		2,527
Consoles		
AM	23,644	39,865
AM-FM	851	39,182
Table Radio-Phonos		
AM	139,273	1,076,629
AM-FM		22
Console Radio-Phonos		
AM	104,161	591,089
AM-FM	2,494	123,235
Battery		
Portable AC-DC	105,338	917,351
Table	201,125	503,586
Consoles	3	647
Auto	1,109,508	43,950
Television		
Converters		
Radio Table Models		5,070
Radio Consoles		
Direct viewing		1,344
Projection		10
Radio Phonos		
Direct viewing	1	
Projection		51
Phonographs		
Phono only	223,886	234,468
With radio attachment	82,706	423,656
TOTAL	3,494,240	10,974,461

We Heard A Speech the other night that somehow tickled us, right from the start. It began: "Members of the youngest profession. . . . .".

TURNER MICROPHONES GIVE YOU ALL 3

Ingenuity and skill in applying sound engineering principles and combining them with modern streamlined styling have made Turner the top name in microphones. Whatever your need for accurate pickup and true life reproduction of voice or music there's a Microphone by Turner to do the job.

THE TURNER MODEL 211 BROADCAST QUALITY DYNAMIC

Engineered for the critical user who is satisfied only by finest reproduction, the Turner Model 211 Dynamic utilizes an improved magnet structure and acoustic network. The high frequency range is extended and the extreme lows raised 2 to 4 decibels. A specially designed precision diaphragm results in extremely low harmonic and phase distortion without sacrifice of high output level. Very sensitive to variations in tone and volume, its accurate pickup and smooth response is free from peaks or holes from 30 to 10,000 c.p.s. Ideal for both voice and music, the Turner 211 is recommended for quality recording, sound system, public address, and remote control broadcast work. It may be used with utmost confidence indoors or out, in any climate or temperature.

SPECIFICATIONS:

- *Output Level:* 54 db below 1 volt/dyne/ sq. cm. at high impedance.
- *Response:* Substantially flat within ±5db from 30 to 12,000 c.p.s.
- *Impedance:* 50 ohms, 200 ohms, 500 ohms, high impedance.
- *Directivity:* Semi-directional. Non-directional when tilted full 90°.
- *Case:* Salt-shaker type in rich satin chrome finish.
- *Cable:* 20 ft. shielded heavy duty 2-conductor removable cable set.
- *Stand Coupler:* Standard 5/8"-27 thread.

Ask your dealer for details or write

THE TURNER COMPANY

905 17th Street N. E., Cedar Rapids, Iowa

TURN TO TURNER FOR THE FINEST IN ELECTRONIC EQUIPMENT

LICENSED UNDER U. S. PATENTS OF THE AMERICAN TELEPHONE AND TELEGRAPH COMPANY AND WESTERN ELECTRIC COMPANY, INCORPORATED

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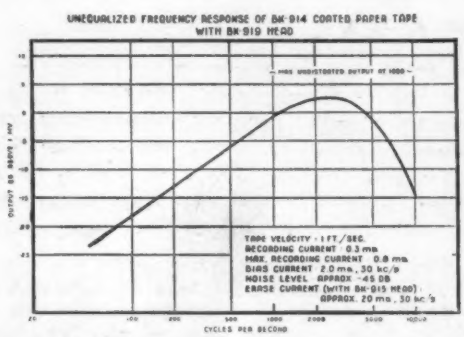
● Low-cost magnetic recording-reproducing components developed by the pioneer and leader in this field open a new world of listening pleasure. Simply constructed erasing, recording and reproducing heads offer "hum-bucking" characteristics. When required the cartridge alone (pole piece and coil unit) may be supplied for incorporation into manufacturers' own head structure.

Brush Paper Tape

- Easy to Handle
- Extremely low-cost
- Can be edited . . . spliced
- Greater dynamic range
- Minimum wear on heads
- Excellent high frequency reproduction at slow speed
- Permanent—excellent reproduction for several thousand play-backs

These latest developments in magnetic recording equipment can now be obtained for radio combinations and other uses. Write today for further information.


UNEQUALIZED FREQUENCY RESPONSE OF BK-814 COATED PAPER TAPE WITH BK-919 HEAD
TAPE VELOCITY - 1 FT./SEC.
RECORDING CURRENT - 0.3 ma.
MAX. RECORDING CURRENT - 0.8 ma.
BIAS CURRENT - 2.0 ma., 30 kc/s
NOISE LEVEL - APPROX. -45 DB
ERASE CURRENT (WITH BK-915 HEAD) - APPROX. 20 ma., 30 kc/s
CYCLES PER SECOND

The Brush Development Co.

3405 Perkins Avenue • Cleveland 14, Ohio

included, manufacturers can sometimes get quicker delivery on them. And at least one tube maker appears willing to cut profit corners in order to support mass production.

Annual Profit of eight industries, expressed as a percentage of investment by RMA excise tax committeeman Joe Gerl (Sonora) is as follows:

Toilet articles 16.52 percent, Automobiles and trucks 15.72, Mechanical refrigerators 13.99, Oil 7.03, Firearms, 5.60, Tires 5.28, Electricity 4.81, Radio receivers 2.67.

Figures are an average based on the four-year period ending December 31, 1938.

Power Companies may prove to be powerful allies in the promotion of television, because the receivers build attractive load. Judging from what utilities have done in the past to promote certain electrical appliances, their help could be considerable.

Commonwealth Edison of Chicago says it looks like the average television receiver will consume 280 watts. Deducting load loss due to the fact that a radio would probably not be used at the same time (deduction for loss of lighting load is not necessary since modern television receivers operate in a normally lighted room) the net load is 215 watts. Assuming that the average television receiver will be in use 3.4 hours in 24, each one would use 731 watts per day.

Antenna Tower Steel is still short but fabricators expect the situation to ease up somewhat this month. Light towers should soon be available 30 to 60 days after placement of orders, heavy ones in 60 to 90 days.

Insulators and wire, rather than steel, are holding up deliveries in some instances.

Embarrassment Of Riches plagues high-frequency heating. So many things can be done with it in industry and elsewhere that engineers are tempted to take a whack at all of them at once.

The smart boys in management

CROSS TALK

▶**GUIDES** . . . The transition of microwaves from military to civilian roles brings up the important matter of waveguide dimensions. During the war, the Army-Navy R-F Cable Coordinating Committee established eight standard sizes of guide. This diversity was necessary because each size is operable over a frequency range of less than two-to-one, whereas the microwave spectrum extends over a range of 15-to-1. Three sizes of guide came into most widespread use, covering the important radar bands at 3000, 10,000 and 30,000 mc. But the civilian spectrum is not so localized. Since the FCC has assigned important services throughout the microwave region, coordination is needed to assure that the bands assigned to the most-used services shall be contained within the coverage of particular sizes of guide. Unfortunately this is not the case. As Moreno has pointed out (ELECTRONICS, p 100, May 1946) several of the fixed-mobile non-government microwave bands can be served only if two sizes of guide are provided for each service. When one considers the complication of providing two sizes of guide, with all the joints and fittings that go with them, for a single line of equipment, it would appear wise to consider either reassigning bands in line with standard waveguide sizes, or alternately, standardizing the wave-guide sizes in terms of assigned services. So far as we have been able to discover, there is no industry or scientific group working on the problem. IRE, ASA, RMA? Who carries the ball?

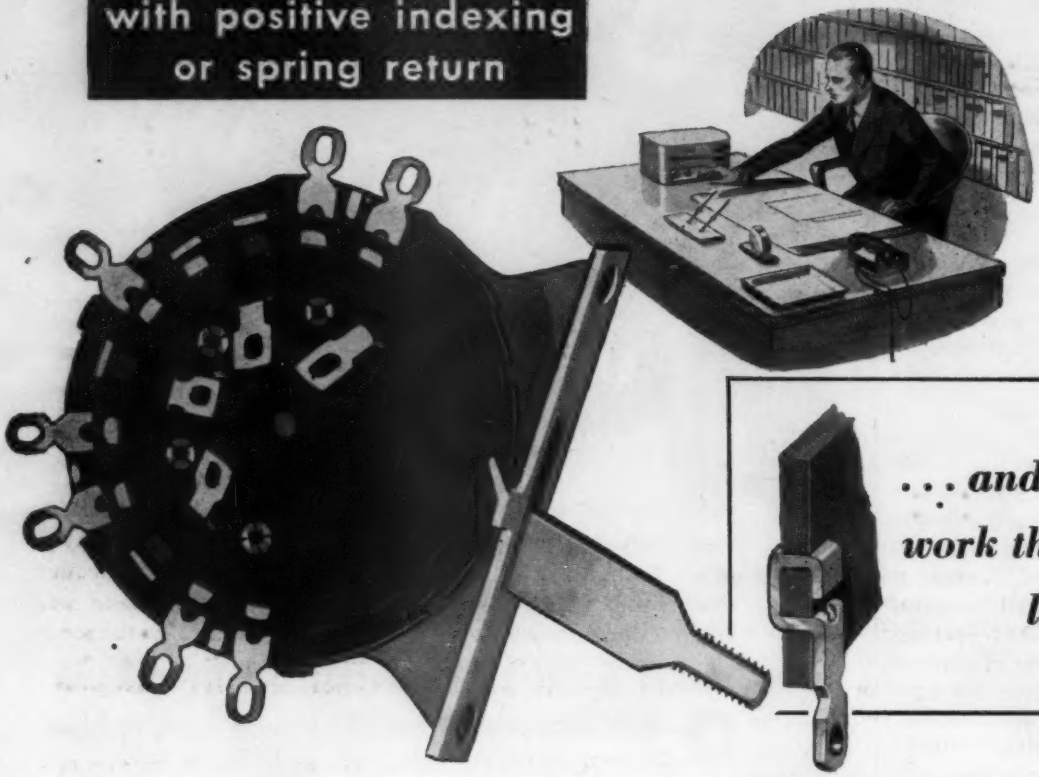
▶**SERENDIPITY** . . . Irving Langmuir, discussing the recent production of man-made snow by dropping dry-ice pellets through clouds, reveals that the discovery was an unlooked-for bonus in a routine investigation. He blamed the good fortune on "serendipity", a word coined by Walpole to mean the gift of finding valuable or agreeable things not sought for. The history of all science, and particularly of electronic science, is studded with such serendipitous occasions. The gift is not arbitrarily bestowed. It comes to those who follow the "procedure of the 10 per cent", a program first brought to our attention by C. J. LeBel: a device (or technique) may be radically improved either by radical redesign, or merely by improving every part (or procedure) by 10 percent. It is on those who conscientiously seek the 10 percent that the goddess of serendipity most often smiles.

▶**VETERANS** . . . Among the hundreds of thousands of soldiers and sailors trained in electronics during the war, many sustained wounds and injuries. They, it seems to us, deserve first consideration in plants and laboratories which can use their skills. The Veterans Administration, listed under U. S. Government in your phone book, can put you in touch with qualified applicants, will provide funds for on-the-job training. Records show that the handicapped worker meets the competition of his able-bodied neighbor in production, outdoes him in loyalty to the job.

▶**TOO MANY** . . . The use of television as an industrial tool is coming into the news, but it's not all good news. We hear, for example, that television is being used to monitor the water level in the boilers of a power-generating station. Without inquiring into the merits of this particular case, we are impelled to ask: Is this necessary? The simplest television system we know of (Block III) uses 55 tubes in a single transmitter and receiver. Simple telemetering systems, fully capable of monitoring water level or any other single-valued quantity, employ a lot fewer than 55 tubes, or no tubes at all. Television has plenty of uses in industry, as a substitute for the human eye, but not as a substitute for a meter, or even a dozen meters. The cause of electronics in industry is not served by such over-engineered applications. The simpler the circuit and the fewer the tubes, consistent with necessary performance, the better. And if a job can be done well without tubes (we admit to a few of these), that's the way to do it.

A New, Better LEVER ACTION SWITCH!

with positive indexing or spring return

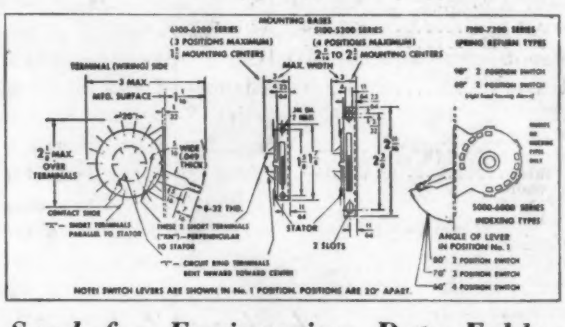


. . . and just try to work this terminal loose!

Although only recently developed and placed on the market, this lever action switch is in big demand. No wonder! It is ideally suited to intercommunications, centralized radio, sound distribution and public address equipment. It gives you a choice of positive indexing *or* spring return. It is as dependable as the leaf spring telephone type switch, yet available at much lower cost.

Consider some of the other "plus" features that set this switch apart: Self-holding terminals of exclusive design are securely clinched to the stator without rivets or eyelets (just try to pull them loose!). All terminals, contacts and ground rings are silver plated for low contact resistance. Constant tension of rotor contact members provides a dependable, self-cleaning action. Insulation is of the highest-grade phenolic.

Positive indexing types of this switch have 48 standard circuit combinations, 24 shorting and 24 positive non-shorting. Spring return types have 17 standard shorting and 17 positive non-shorting circuit combinations. Write for engineering data folder or see your nearest Mallory distributor.



Send for Engineering Data Folder

The Engineering Data Folder for the new Mallory Lever Action Switch contains complete specifications, available circuit combinations with respective terminal locations, dimensional drawings—everything the engineer needs to assist in selection of the particular Mallory Lever Action Switch to best handle the application.

P. R. MALLORY & CO. Inc.

MALLORY SWITCHES

(ELECTRONIC, INDUSTRIAL and APPLIANCE)

P. R. MALLORY & CO., Inc., INDIANAPOLIS 6, INDIANA

FCC Views Television Advances

Color vs black-and-white contest sharpens as industry demonstrates competing equipment at hearing. New monochrome equipment shows great increases in brightness and contrast. "Mixed highs" technique for simultaneous color system revealed

FOR THE FIRST TIME in its long history of adjudicating the standards and allocations of television, The Federal Communications Commission recently brought operating equipment into the court room for a first-hand check on the claims of conflicting systems. The occasion was a three-day session at the District Court House in New York and at the RCA Laboratories in Princeton, during which black-and-white and color systems were demonstrated while technical measurements of the brightness and resolution of the images and their ability to withstand external light, were made by engineers.

The major issues under discussion have already been treated in these pages[1, 2]. The Columbia Broadcasting System has petitioned for immediate commercialization of their sequential color system, while the opposition has argued that this system cannot at present offer the same service as the existing black-and-white system. In particular, the Radio Corporation of America has urged that the simultaneous system of color is preferable to the sequential system, since it can be integrated with the present black and white standards, thus avoiding obsolescence of equipment now being sold to the public. The demonstrations were intended to illustrate both sides of the controversy.

Sequential Color Systems

During the first day of the demonstration, CBS and Bendix showed sequential color receivers of identical internal design, picking up both live and film programs from the CBS transmitter about two miles away. It was shown that these pictures (on ten-inch tubes, magnified optically to 12-inch size) had a highlight brightness of 10 to 20 foot-lamberts, and that they had high resistance to external illumination because of the protection afforded by the rotating filter disk. On the second day of the session, DuMont Co. showed black-and-white pictures on a comparative basis. Three sets having 12, 15 and 20-inch tubes with aluminum-backed phosphors, and operating at about 20,000 volts, were shown. The highlight brightness of the 12-inch tube was measured at 500 foot-lamberts and on one occasion as high as 750. A neutral-gray optical filter, admitting about 9 percent of the light and matching the average transmission of the color disks, was placed before the monochrome images and the protection against ambient illumination, similar to that of the color receivers, was demonstrated.

At Princeton, RCA demonstrated its simultaneous color system, producing a 15-by-20-inch picture of about 5 foot-lamberts highlight brightness. The interchangeability of the simultaneous system with the present black-and-white standards was demonstrated by receiving the commercial monochrome

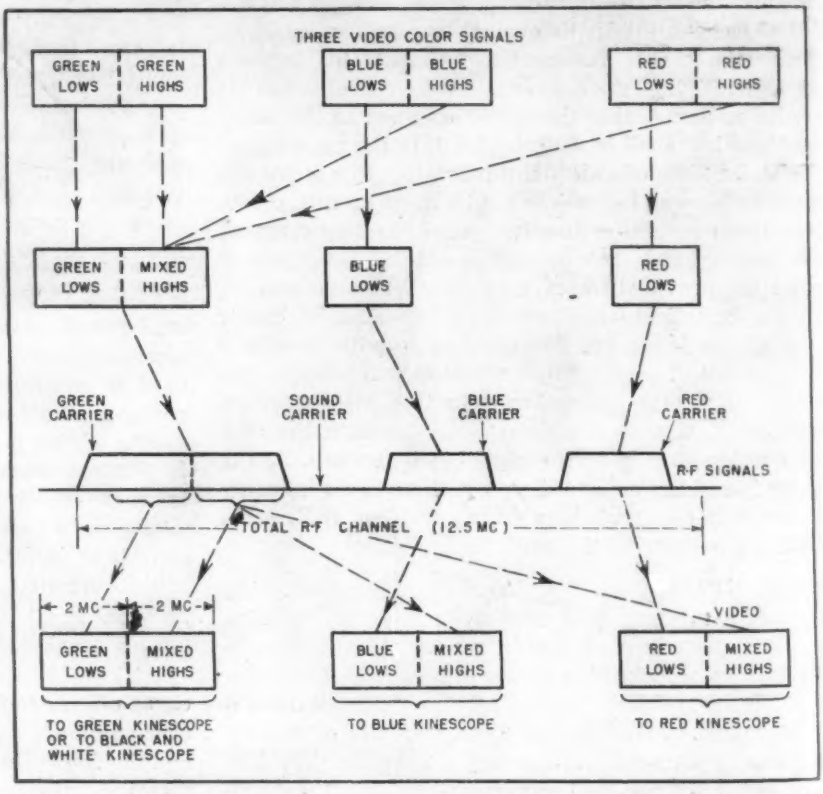


FIG. 1—By transmitting all fine detail of the image through the green channel, RCA mixed-highs system reduces bandwidth requirements of simultaneous system by 2mc. achieves effect of black plate in color printing.

Television enters the court-room. FCC commissioners view Bendix and CBS color receivers side by side with DuMont monochrome units, as Peter Goldmark (at left of woman court reporter) testifies

NBC transmissions from New York on the color receivers, and (by the use of an r-f converter) receiving the color transmissions in monochrome on standard production model monochrome receivers. The channel width employed by RCA was 14.5 mc, as compared with 16 mc for the CBS system.

"Mixed-Highs" System

Following this a new proposal for transmitting color images on a still narrower bandwidth was revealed, the so-called "mixed-highs" system. As shown in Fig. 1, the high video frequencies produced by the three color chains are separated and combined, then transmitted over the green r-f channel, which has full bandwidth. The red and blue channels transmit only the low-frequency components. As a result, the fine detail of the image, reproduced by the high frequencies, is reproduced in shades of gray, whereas the broad areas of the image (larger than $\frac{1}{16}$th to $\frac{1}{8}$th-inch on a 15 by 20-inch screen) are reproduced by the low frequencies of the three channels in their respective colors. This technique is very similar to that employed in color printing, in which the detail of the image is carried by a fourth plate, the so-called black-printer, which carries black ink and reproduces the detail in shades of gray, over three primary colors imprinted by three other plates.

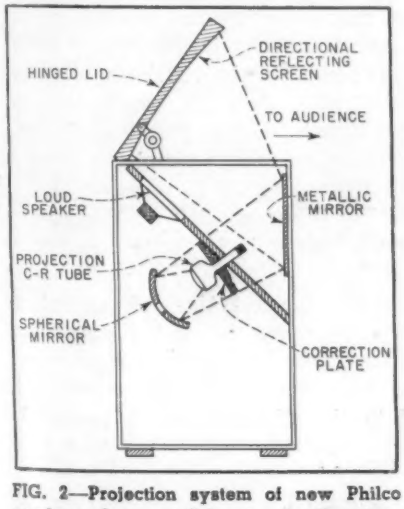


FIG. 2—Projection system of new Philco receiver, shown at Princeton for first time. The directional reflector confines light to eye level, thus increasing brightness and contrast four times over comparable projection units

The system permits a 525-line color image to be transmitted over a 12.5-mc channel, while still preserving conformity of the green channel with the black-and-white standards, so that the green image may be received in monochrome on existing receivers. According to E. W. Engstrom, who conducted the demonstration, no difference between the images of the normal simultaneous system and the mixed-highs system can be seen at a viewing distance greater than four times the picture height. No difference was noted by the viewers when the image was switched from one system to the other.

Curved Viewing Screen

The final demonstration at Princeton was something of a sensation, the first public showing of the long-rumored Philco projection black-and-white receiver, shown schematically in Fig. 2. A full program of live-talent, remote pick-up, and film programs transmitted by NBC in New York was reproduced for the Commission, press and other witnesses. This receiver produced a 15 by 20-inch picture, from a four-inch projection tube and Schmidt optical system, arranged within the cabinet to fit into a minimum of space. The picture had about 4 times the brightness of similar projection pictures previously shown and displayed a vast increase in contrast and resistance to external light. The picture was viewed comfortably with sun streaming in the windows.

The secret of this receiver is the use of a directional viewing screen, consisting of a coating of unannounced composition on a curved aluminum back. This screen confines the reflected light to a small angle, measured in the vertical plane, while permitting it to spread over a range of perhaps 100 degrees in the horizontal direction. Thus many viewers around the set, seated with their eyes at screen level receive an equally bright picture, but little light is lost in the direction of the floor and the ceiling. The screen action also prevents external light from being reflected into the eyes of the observers and thus preserves high contrast even when the ambient light is very high.—D.G.F.

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HEATING

Experimental Westinghouse setup of microwave heating equipment. Liquid in container held near opening in waveguide is heated by r-f energy

MANY worthwhile applications of dielectric heating are impractical at the present time because of limitations in heating speed imposed by the necessity for use of radio-frequency power at conventional frequencies. Frequencies in the microwave region offer possible future solution to these types of applications if means can be found for generating sufficient power on a continuous rather than pulse basis. The purpose of this paper is to look into the future of microwaves and expose insofar as possible at this time the techniques that appear to be rational for industrial heating applications.

The only microwave tubes in large-scale production at present are resonant-cavity magnetrons for pulsed operation. Though they give peak power outputs of a megawatt or more, the average power is seldom over 1 kw, which is just on the verge of being useful for heating purposes. Furthermore, pulsed operation is seldom useful for heating, as the work piece is subject to large voltages during the operating time and must be suitably arranged to prevent breakdown.

The two tubes which show the greatest promise for future work in dielectric heating are the split-anode magnetron and the resnatron. The split-anode magnetron will develop 10 kw continuously with an efficiency of 50 percent at wavelengths of 40 to 90 cm; though there is no production of this tube at present, it could be made if the need arose.

The resnatron type of tube is the only source available in the 50-kw range. It is a beam-type tetrode which can be used either as an amplifier or oscillator at wavelengths of 10 to 100 cm, with continuous operation at an efficiency of 25 to 60 percent. It was put into small-scale production by Westinghouse, some twenty tubes having been made.

Assuming a suitable source of r-f power, the problems of making this power available for dielectric heating differ considerably from those commonly encountered with conventional frequencies, it is no longer possible to use the ordinary open-wire transmission line to convey the power from the source to the work, due to the excessive loss by radiation from such a line at microwave frequencies.

Coaxial type transmission lines are satisfactory for wavelengths as low as 10 centimeters or less under certain conditions, but at wavelengths around 10 cm and sometimes up to 60 cm or above it becomes of material advantage to use waveguides for the transmission of power.

The problems of impedance matching in waveguides are similar to those for coaxial lines. Variable-length stubs may be used, and there are many ways of terminating a waveguide so that no reflection will occur from the termination.

If the load to be matched is constant, a fixed diaphragm may be soldered into the guide at the correct place to effect a match. If the load is constantly changing, then one must have a continuously adjustable matcher, such as a two-stub tuner.

Textile Applications

In many industries we have dielectric heating problems involving the drying, curing, or setting of resins or glues in continuous processes. Take the textile industry as an example. They dry cloth after dyeing, both in bulk and on a continuous basis. Printed fabric requires a rapid drying cycle for the dyes and inks used. In the paper industry we also encounter drying of the material on a continuous sheet basis at high speed.

At conventional frequencies where power in sufficient quantity may be available to accomplish the drying of paper and textiles we are still limited by the inability to get that power into the work. The amount of power transferred into the work, once frequency is set, varies with the square of the voltage across the electrodes. Actually, power is proportional to the product of frequency, loss factor, and the square of the voltage.

For thin materials such as paper and cloth it is impossible to apply sufficient voltage across the electrodes at conventional frequencies, as flashover between the electrodes takes place long before any appreciable amount of power is coupled into the dielectric work material. The answer obviously is to use a much higher frequency.

Figure 1A illustrates how a cavity resonator might easily be used to put power into rapidly moving thin sheet material. We have a dielectric field of uniform character

WITH MICROWAVES

Suggested methods of utilizing waveguides for applying microwave energy to moving or stationary wires and threads, sheets, or irregularly-shaped objects to achieve uniform dielectric heating, and survey of tubes offering possibilities for continuous operation

By J. MARCUM and T. P. KINN

Research Laboratories, Westinghouse Electric Corporation, East Pittsburgh, Pa.
Industrial Electronic Engineering, Baltimore, Md.

only in one dimension, in the plane of the E field which is a maximum at the center of the cavity or guide. By passing the material through slots at the top and bottom of the cavity we subject it to the strong dielectric field, but because of the standing wave effect along the length of the cavity the material will be heated unevenly if passed straight through the cavity. By making the entry and exit points a half-wavelength apart we obtain a condition which insures uniform heating as the material passes through the cavity.

Heating Sheets of Material

It is easy to picture this method of coupling microwave power as being used to perform many commercial heating jobs, including the bonding and drying of wallboard materials, floor covering materials such as linoleum, and plastic-bonded cork materials. Continuous curing of sheet rubber, plastics, and synthetic materials and production of plywood on a continuous basis are still other likely applications.

It may be possible and in some cases desirable to heat sheet material as shown in Fig. 1B. Here the microwave or radar antenna is put to work as a means of coupling energy into a material to be heated. An outstanding property of microwaves is this ability to concentrate them into a narrow pencil-like beam by means of a reasonable antenna structure. A so-called bedspring antenna designed to have uniform distribution of field can be used to heat large sheet material. The shape of such an antenna is flexible to a degree and therefore lends itself to the efficient heating of various widths and shapes of material.

Drying Applications

If we turn from sheet material to such items as wire and thread we again find innumerable problems where microwaves may be applied. Textiles such as rayon and nylon must be cured, dried, and the twist set. Rubber thread material, both synthetic and pure Latex, must be cured. Many insulating coatings on wire, either rubber, synthetic, or enamel, must be dried or cured. All of these operations must be accom-

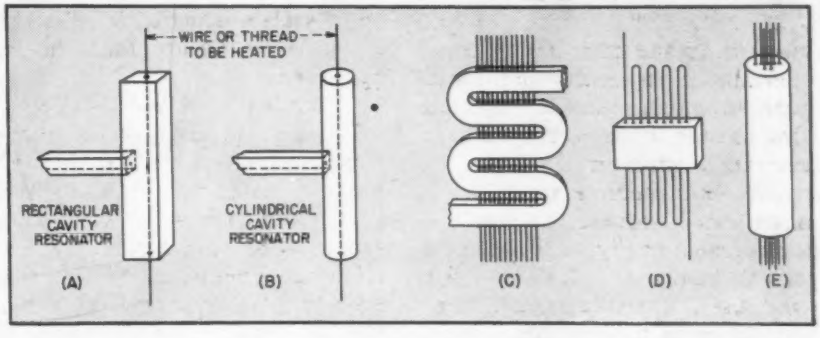


FIG. 2—Five methods to transferring microwave energy from a waveguide to a wire or thread for dielectric heating

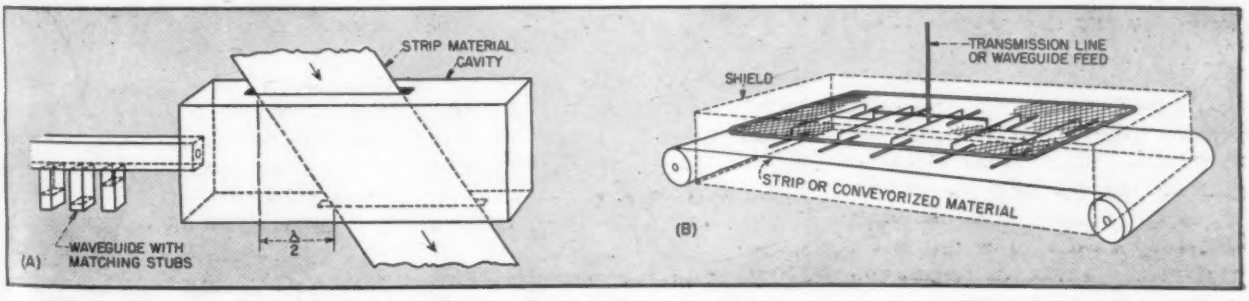


FIG. 1—Running continuous strip material through a resonant cavity at an angle as at *A* gives uniform dielectric heating. At *B* is shown one possible method of using a radar bedspring antenna for dielectric heating of moving material

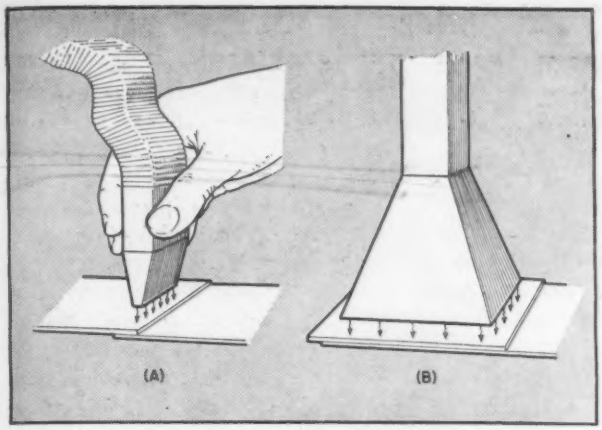
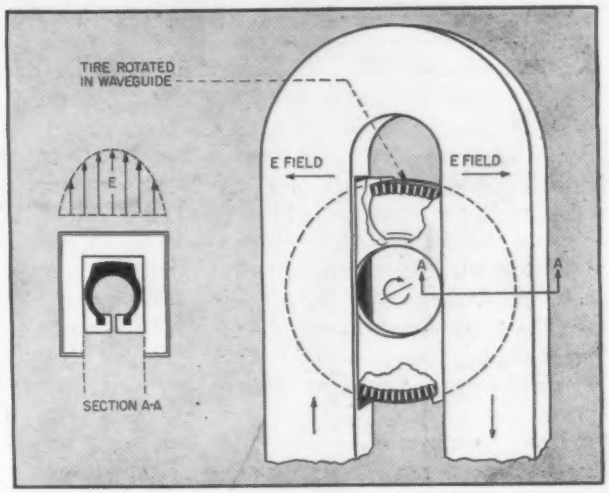


FIG. 5—A method of concentrating microwave energy at a narrow joint by means of a flexible waveguide is illustrated at A, and use of a divergent taper at the waveguide aperture for spreading the heating energy is shown at B

FIG. 6—Method of curing automobile tire by means of microwave energy



as the vinylidene chloride materials. Here again conventional frequencies are relatively slow and microwave energy properly applied may be the answer. By concentrating extremely high frequencies it may be possible to bond such sheet materials at an unbelievable rate with rather simple handling equipment. By making use of presently available flexible waveguide material, such a bonding operation could be made semiportable. Figure 5 illustrates two such possibilities of the future where concentration of power is desired or when larger surfaces must be bonded.

Curing Rubber

The rubber industry is also a large user of r-f power at conventional frequencies. Many production problems in this industry, however, await solution by the use of higher frequencies. Being a very poor thermal conductor, rubber lends itself naturally to dielectric heating. Where speed and quality are of prime importance, r-f energy supplies the answer. Probably one of the most desired places for quality in a rubber product is the tire we put on our own automobile. Radio-frequency curing of rubber in that tire could give that extra something we are all looking for in a tire. Microwave energy may again be the final answer, and Fig. 6 illustrates one possible method for accomplishing such a production problem. The field distribution within a cavity is put to advantage to assist in a uniform heating and therefore uniform curing job.

Food Industry Applications

The largest industry of them all, the food industry, is just becoming conscious of the potential advantages offered by r-f heating. The sterilization, blanching, and cooking of foodstuffs are all possible applications for r-f energy. Recent development work indicates that very large advances in quality may be possible in the future by using r-f energy for blanching and sterilizing. These same developments indicate the need for higher frequencies in the microwave region to produce the desired results at the volume and speed normally used in processing foods.

The future is sure to bring pressure on the electronic industry for equipment to process all types of foodstuffs. This pressure will become apparent as the food technologists progress in their present studies of r-f blanching and sterilization.

Many other applications will present themselves in the food industry. For example, much speculation on the cooking of various foods has stimulated the imagination and even brought forth the desire to rapidly defrost and cook a plate full of frozen meat, potatoes, and vegetables. Unequal heating of the various foodstuffs when subjected to an r-f field makes this problem impractical at conventional frequencies. By using the unequal field distribution found in a cavity resonator it may just be possible that a suitable combination of frequency, cavity size, food stuffs, and proper orientation of the food in the field of the cavity would give a means of accomplishing the desired result.

Conclusions

Throughout this paper it has been the attempt to show the present techniques of generating and handling microwave energy and speculate on how these known techniques might be applied to industrial heating problems. Some of the suggested methods of use may appear somewhat fantastic, but it is believed that the principles involved are fundamentally sound. Therefore, the ideas presented should serve to stimulate thought and development.

It must be clearly recognized that this paper is in the nature of an exploratory trip into the future and is not intended to indicate that present techniques utilizing presently available frequencies will in any sense have to be completely replaced.

It is more necessary that the heating development engineer study the use of microwave energy in industry and thereby create a demand, a big demand for high power at microwave frequencies. If this demand is sound the tube development engineer will have incentive to create what is needed, and microwave techniques in industry will become a reality.

plished by heat applied at high speed. Again, with conventional frequencies it has been impossible to couple energy into such materials at a rate suitable for production requirements.

Such production problems may some day be solved by microwave energy applied as shown in Fig. 2A and 2B. Here we have a long cavity through the center of which we can pass the wire or thread that is to be heated. The possibilities of such an arrangement are easily visualized. Energy transfer of such a system may be rather inefficient, in which case the arrangement shown in Fig. 2C, 2D, or 2E may become more practical. These same means of increasing coupling efficiency could be applied to sheet material.

In the lumber industry we find many problems of gluing waiting for solution by dielectric heating.

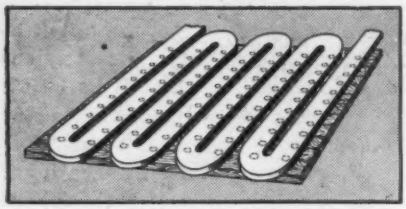


FIG. 3—Arrangement of waveguide with radiating holes for spot-tacking of glue line simultaneously at many points in edge-glued lumber

Spot gluing and edge gluing could be accomplished readily by the concentrated fields made possible through the use of openings in waveguide structures. Holes in waveguide structures would apply concentrated fields to the glue line as illustrated in Fig. 3. The continuous bonding of plywood by a method similar to either Fig. 1A or Fig. 1B would make possible a process which to date has not been tackled because of the major difficulties encountered by conventional press designs and curing methods.

Preheating Plastics

The plastics industry is now a big user of r-f energy for preheating material prior to molding. Conventional frequencies adequately supply the heating rates normally used for hand-fed press operation. High-speed automatic operation could now use r-f energy to advantage, however, if sufficiently fast heating rates could be obtained. The answer again will probably be microwave energy, possibly applied as shown in Fig. 4A. Jet molding on an automatic basis could easily become one of the faster means of molding thermosetting material.

The problem of preheating molding material is one of uniform heating. Because of the uneven field distribution in a guide or cavity, special means are necessary to provide a uniform field for uniform heating. Figures 4B, 4C, 4D, and 4E illustrate possible ways of obtaining this uniform field. Figure 4B shows two electrode plates with strap tuning inductance so placed in a guide that the inductance straps couple to the magnetic or H field. Figure 4C shows the electrode as a part of a quarter-wavelength antenna located within a cavity. Similarly, Fig. 4D suggests adjusting the thickness of the cavity in the E field dimension to suit the thickness of material, the material being confined to only the central part of the guide. The removal of energy from a guide to apply it to external electrodes can be accomplished by coupling at two points a half wavelength apart and selecting proper odd quarter-wavelength leads as shown in Fig. 4E.

Microwave energy piped to numerous press positions from one central generator may be the future answer to many a molder's present problems. A central generator supplying many operating positions, as in Fig. 4F, has not proved too satisfactory at conventional frequencies because of the many switching, matching, and voltage problems encountered. The ease with which any degree of energy desired can be removed from a waveguide makes such problems as voltage and switching simple. There is still the problem of suitable match of the guide to the generator, but here again the problem is actually simplified by the relatively simple means we have of obtaining adjustable capacitance and inductance at microwave frequencies as compared with the limitations of lumped impedances at conventional frequencies.

In the field of plastic and synthetic materials there is the rapidly growing demand for bonding or sewing of sheet material such

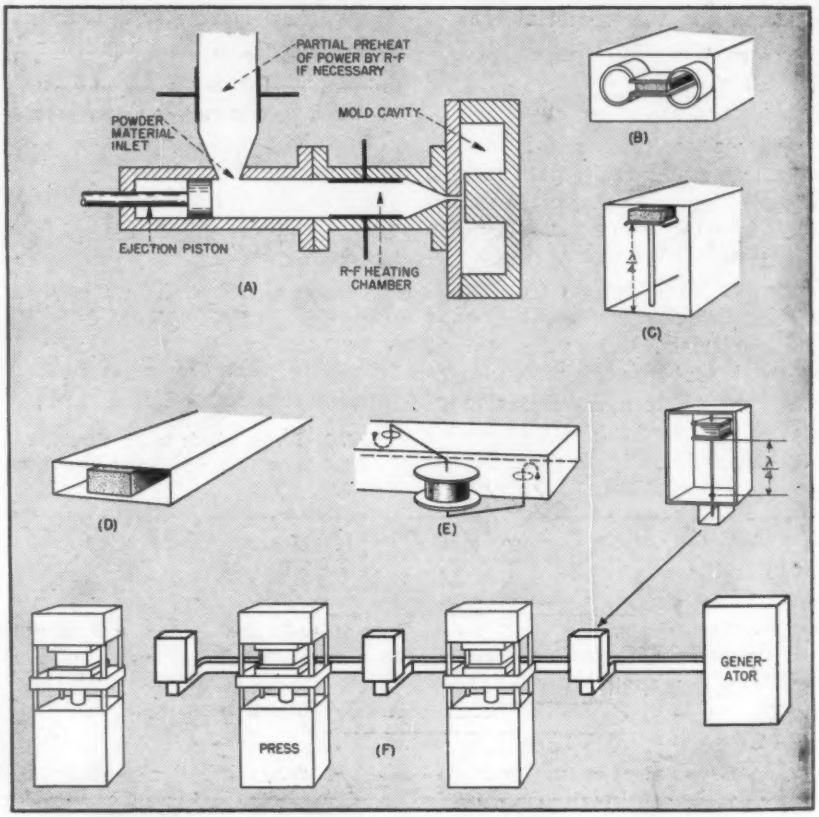


FIG. 4—Suggested methods of utilizing microwave energy in molding of plastics

RELAY SYSTEM

Wideband frequency-modulation equipment operating on 1,350 mc handles black-and-white video signals. Equipment is equally useful for intercity multiple link or studio-to-transmitter work. Heterodyne modulation and remodulation are employed

Several characteristic features of the equipment will be apparent from the foregoing discussion. Most important is the elimination of all video amplifiers except the simple ones at the transmitting and receiving terminals. Next is the provision for wideband deviation and amplification. A third feature is the use of heterodyne modulation and remodulation, which provides for faithful frequency conversion without demodulation to video frequencies or to an amplitude-modulated signal. Other important circuits which will be discussed herein include the following:

(1) Design of i-f amplifiers for good phase response.

(2) Use of sync-tip afc circuits with a frequency-modulated carrier.

(3) Use of constant-impedance coupling networks between chassis units.

(4) Novel circuitry for i-f amplifier design.

(5) Novel design of r-f heterodyne mixer stage.

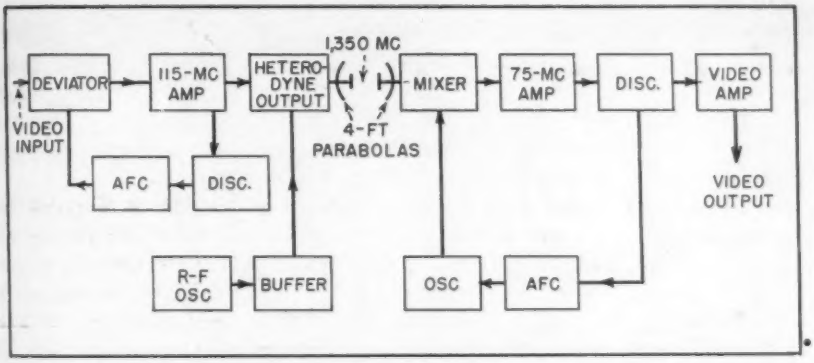


FIG. 1—Block diagram of studio-to-transmitter link equipment, showing video transmitter, at the left, receiver at the right, and the radio path between them

Transmitter Circuits

The various transmitter components are described in the order of their use in a studio-to-transmitter link. The video amplifier, which is conventional, includes an input cable impedance-matching resistor, a gain control (for adjusting deviation), and a push-pull video amplifier having a gain of 10. With 1 volt peak-to-peak input, the amplifier output tubes will deliver 7.5 volts in each plate circuit. These signals, of opposite polarity, are applied to the repellers of a pair of

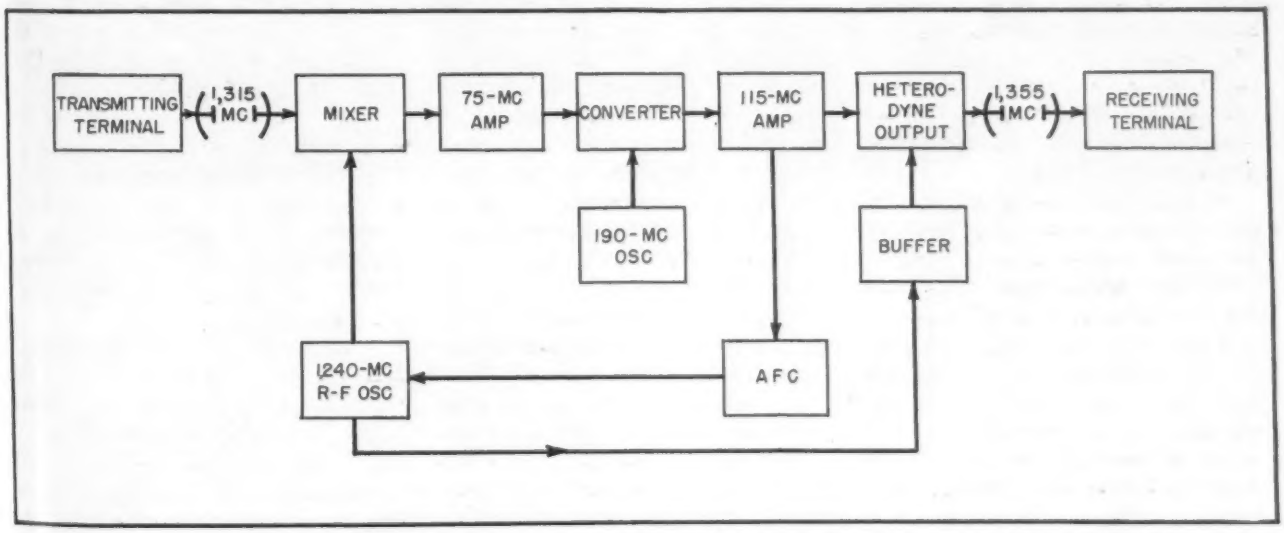
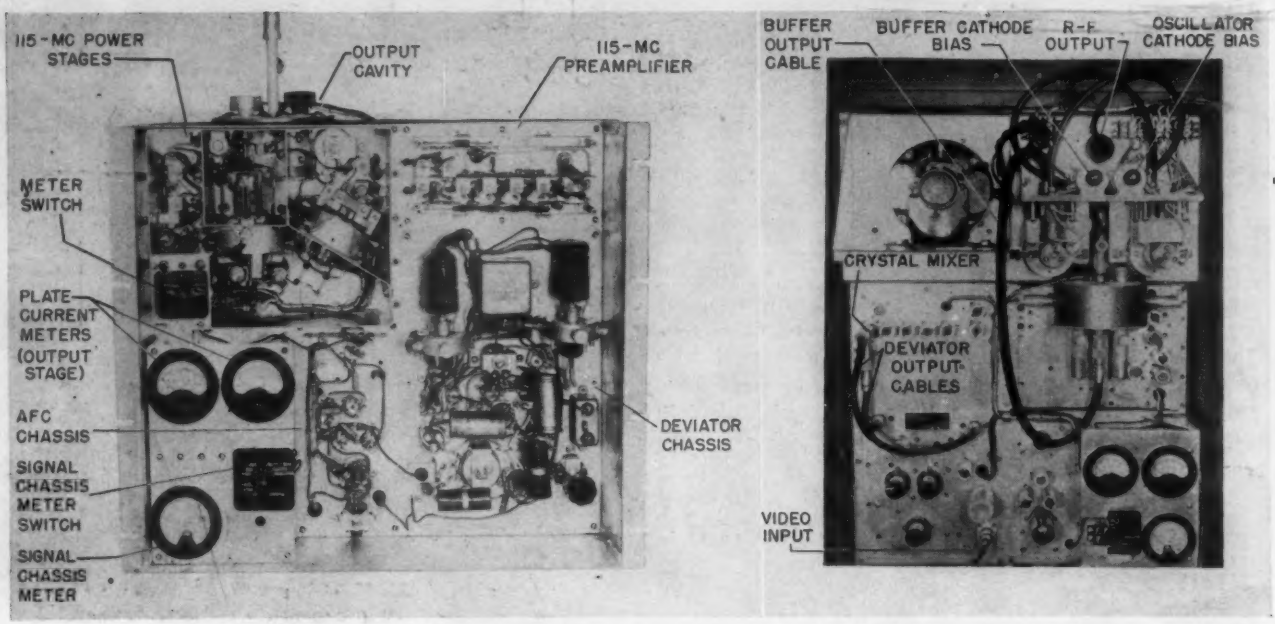


FIG. 2—Diagram of 1,315-mc television relay system. Transmitting terminal block at the left and receiving terminal block at the right are similar to the units in the studio-transmitter equipment diagrammed in Fig. 1

UHF TELEVISION



Front (left) and back views of a typical relay transmitter chassis

By WILSON BOOTHROYD

Project Engineer, Research Division
Philco Corporation
Philadelphia, Pa.

OUR ENGINEERS have recently completed and tested a radio relay system suitable for the transmission of black-and-white television signals. The basic aim of the project was to provide equipment for intercity multiple-link radio relaying, and to develop similar equipment suitable for studio-to-transmitter or remote pickup relaying. The present equipment operates in the 1,350-mc band and consists of two basic combinations of components, outlined in the block diagrams of Fig. 1 and 2.

Figure 1 is a block diagram of the studio-to-transmitter link. A composite television signal (video) of one volt peak-to-peak value, with the synchronizing signal negative, is required at the input. This input signal is applied to a deviator unit, which amplifies the video signal and uses it to deviate oppositely a pair of reflex klystron microwave oscillators. The output signals from these oscillators are mixed in a crystal to produce a difference frequency.

The difference frequency constitutes an f-m signal in the 115-mc region. The peak input signal, corresponding to the voltage difference between the tip of the synchronizing signal and the peak white of the video signal, will cause a swing of 13 mc in the difference frequency. The difference frequency corresponding to the synchronizing pulse peak is established at 107 mc. The minimum difference frequency of the microwave oscillators is controlled by an afc circuit, so that the sync pulse is transmitted at a constant frequency, regardless of picture content.

The difference-frequency signal is amplified in a wideband i-f amplifier having a pass band from 105 to 125 mc. The output signal from this i-f amplifier and an r-f carrier are applied to a pair of output tubes which serve as a heterodyne converter, from which is derived an r-f output signal whose frequency is the sum of the frequencies of the two input signals, i.e., a signal in the 1,350-mc region having an output spectrum 20-mc wide. The r-f output is radiated from a 48-inch parabolic reflector antenna system. For convenience of installation and portability, flexible cable is used to connect the antennas to both the transmitter and receiver.

The receiver is a superheterodyne using a crystal mixer, a velocity-modulated local oscillator tube, an i-f amplifier having a pass band greater than from 65 to 85 mc, a discriminator and video amplifier, and an afc circuit for controlling the local oscillator.

Figure 2 is the repeater station diagram. Here, in comparison with the receiver of the studio-to-transmitter-link, the discriminator of Fig. 1 has been replaced by an i-f converter and a crystal-controlled amplifier. The r-f carrier oscillator for the transmitter is also used as a local oscillator for the receiver.

their screen voltages. Then grid currents may be successively metered while a sweep-frequency signal is applied to the amplifier for alignment.

The afc and a monitor are included in the i-f chassis. The discriminator on this chassis is unusual in that it is tuned for an unsymmetrical response, as shown in Fig. 6A, having no output at 107 mc and a linear characteristic for frequencies from 105 mc to 119 mc. This response curve is desirable for two purposes. First, for afc purposes, the discriminator output is d-c coupled to a 1N34 crystal which is poled as shown in Fig. 6B to pass only signals of positive potential. If the i-f signal is within the proper frequency region of the spectrum, the crystal will pick off only the peaks of the sync pulses. These sync pulse peaks are then amplified, detected, and applied as d-c bias to a 6SJ7 d-c amplifier. This amplifier is operated between such potentials that its plate voltage is at the proper potential for the repeller of one of oscillator tubes of the deviator.

A variable resistor in the amplifier cathode is used to obtain the initial adjustment. The circuit operates in such a manner that, should the frequency difference of the two deviator oscillators at the time of the sync pulse be other than normal, more or less sync pulse will be picked off from the discriminator circuit and used to provide a correcting voltage for application to the grid circuit of the d-c amplifier to modify the frequency of one of the oscillators by repeller tuning. Both the amplifiers in the afc circuit are operated at high gain, so that drift will be negligible, and hence the intermediate frequency will be held constant within the limit of accuracy of the discriminator tuning.

The second function of the unusual discriminator curve is to provide a means of monitoring the deviation. When the deviation is normal, the video signal viewed at the monitor output point will show slight saturation of the peak white signal when viewed on a standard oscilloscope. This is caused by the frequency corresponding to the negative peak of the discriminator curve. If deviation is subnormal there will be no saturation, or if overnormal the saturation of the peak white signals will be severe. Since this circuit is only a monitor circuit and is not a part of the signal amplifier, there will be no distortion of the output signal even with saturation in the monitor channel.

R-F Power Amplifier

The power amplifier terminates in the circuit of Fig. 7, which shows the heart of the transmitter, the r-f heterodyne output stage. The final stage of the i-f amplifier is an 829B tube, with the output coupled by susceptance into the single-sided circuit which drives the output stage grids.

The output stage consists of a cavity resonator housing a pair of 2C39 tubes. The main body of the cavity is a cylinder with its axis perpendicular to the grid plane. The grid plane, insulated from the cavity shell, is supported in the equator of the cavity and contacts the output tube grids, thus forming separate plate and cathode cavities within the main shell. The cathode cavity includes transmission lines whereby the filament connections are made, each line being tunable by means of capacitance adjustments. The cathode cavity is excited by a carrier-frequency signal from the oscillator and buffer stages in the second order $TE_{01,2}$ mode, in such a way that an equipotential plane extends between the two tubes.

The grid plane is effectively grounded at the carrier frequency by a pair of open-circuited quarter-wave lines which are tuned by means of polystyrene slugs. These lines also form the principal me-

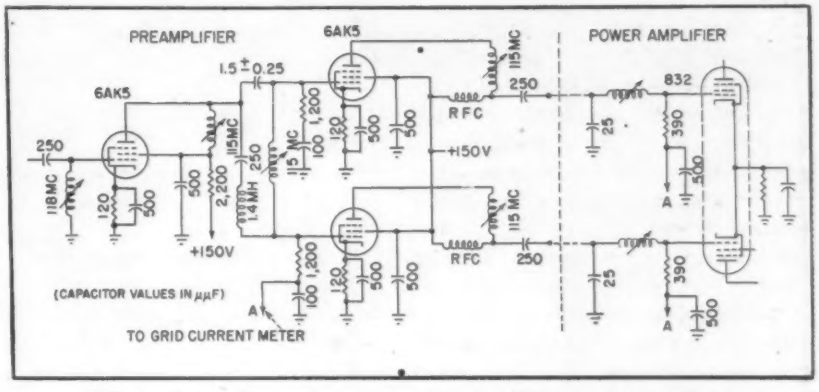


FIG. 4—Preamplifier output, and power amplifier input connections

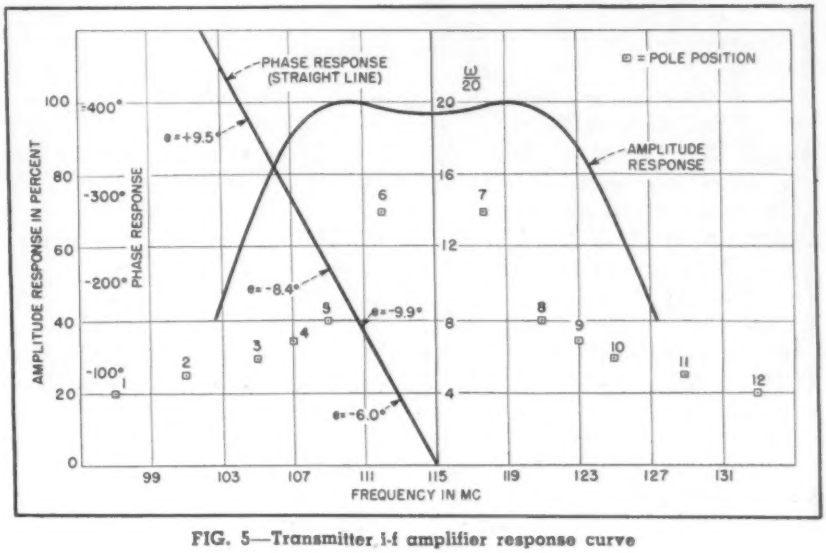
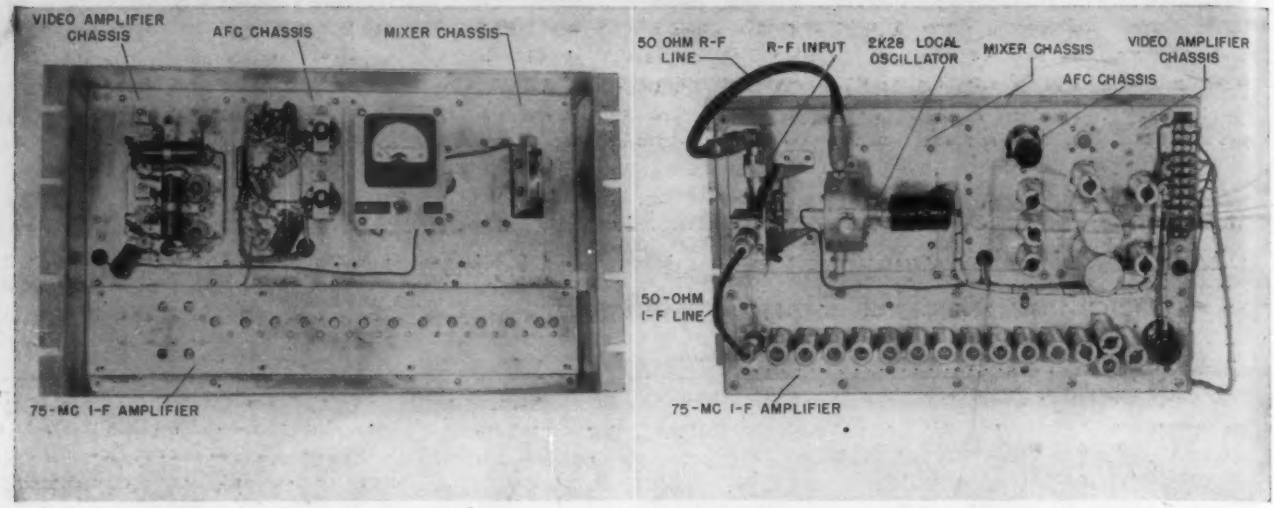


FIG. 5—Transmitter i-f amplifier response curve



Front (left) and back views of a typical relay receiver chassis

2K28 oscillator tubes to deviate these tubes oppositely and thus increase their frequency difference compared to their frequency difference during the peak of the sync pulse.

Conventional a-c coupling from the video amplifier to the oscillator repellers is unsatisfactory, because it would permit the drifting of the frequency which corresponds to the peak of the sync pulse, with changes in picture signal content. Hence leveling diodes are employed across the coupling resistors so that the repeller voltage (and hence the oscillator frequency) during the sync pulse is determined by d-c bias. By this means the sync pulse is always transmitted at the same i-f frequency. This makes possible the type of automatic frequency control described below, as well as other advantages.

In order to obtain linear deviation of the oscillator frequency over an adequate range, without requiring excessive voltage swing, the oscillators are loaded by short transmission lines which are coupled to the oscillators and serve as dissipative elements to broaden the oscillator frequency characteristic. Figure 3 shows the typical curve of one of the oscillator stages under various load conditions, as well as the construction of the dissipative lines.

The microwave oscillator output signals from the deviator are mixed in an untuned mixer assembly mounted on the i-f preamplifier. The first four stages are conventional single-tuned stages whose frequencies and Q values are as prescribed by the overall amplifier pole diagram to be described. To change from a single-sided amplifier to a push-pull stage, susceptance coupling, using a capacitive susceptance in one arm and an inductive susceptance in the other, is used. This simple coupling arrangement has been found to give good performance.

Because the i-f preamplifier and power amplifier were constructed on separate chassis units, the preamplifier output circuits were so designed that variations in distributed capacitance across the power amplifier input terminals may be easily tuned out. Figure 4 shows the preamplifier output and power amplifier input circuits. The power amplifier consists of two stages of push-pull amplifiers terminating in a single-ended connection for driving the grids of the tubes in the output cavity resonator. To obtain maximum mutual conductance, these i-f amplifier tubes are operated from a 200-volt supply at maximum current. The transition from push-pull to single-ended output is again accomplished by susceptance coupling.

The i-f amplifier (including both preamplifier and power stages) consists of a number of single and double-tuned circuits whose resonant frequencies and Q values are arranged in accordance with the polar diagram of Fig. 5. As shown, the tuned circuits are symmetrically disposed about the axes, and produce the indicated amplifier response. This amplifier was designed for best phase response with pairs of poles assigned to appropriate stages. Each amplifier in the system was designed for optimum phase response and good amplitude response, consistent with efficient use of available tubes. Additional poles required by the r-f and antenna circuits are tuned to center frequency and made adequately broad. To facilitate alignment of the 115-mc power amplifier, all stages are designed so as to permit lowering of

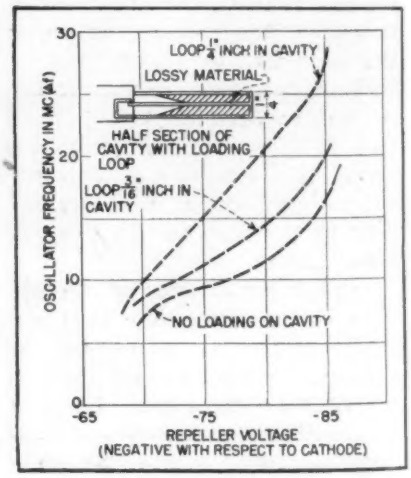


FIG. 3—Typical reflex klystron oscillator tuning response with various degrees of loading

cause of the simplicity of the layout and the ease of alignment and servicing. This amplifier has a mean gain per stage of about 2.7 and is so simple in construction that its coils can be preadjusted on a Q-meter before installation.

As tubes may be replaced without retuning, the circuits are effectively fixed-tuned. The amplifier operates effectively on an r-f input of approximately 95 db below 1 watt, although its normal operating range is at a much higher level. The receiving output is 1 volt peak-to-peak across 70 ohms (corresponding to the input level). Thus the output signal corresponds in all respects to the input signal.

The i-f frequency bands are selected primarily for their adaptability to the double superheterodyne amplifier of the repeater station. An input signal (from a previous transmitter) is heterodyned against an r-f oscillator signal to obtain a 75-mc i-f signal. This is amplified in an amplifier identical to that of the receiver and fed to an intermediate converter, where it is again heterodyned against a crystal-controlled 190-mc signal to produce a 115-mc signal. Again a 115-mc amplifier identical to that of the transmitter is used to drive another output stage. By maintaining a difference between the r-f input and output frequencies equal to the difference between the i-f frequencies, and by transposing the local oscillator frequency from below the incoming signal to above the incoming signal on alternate repeaters, a minimum number of amplifier designs are required. In repeater stations, either the afc is locked on the incoming carrier, or else stabilized oscillators are used.

SYSTEM PERFORMANCE

Transmitter Power (20 watts)	+13.0 db	
Transmitter Cable Loss (30 Ft of RG-17/U cable)	− 1.5 db	
Space Loss (31 miles, one 4-ft and one 8-ft parabolic antenna with 65 percent antenna efficiency)	−76.5 db	
Receiver Cable Loss (120 Ft of RG-17/U cable)	− 6.5 db	
Signal Level		−71.5 db
Crystal Conversion Loss (this figure is 6 db below minimum due to the bandwidth and impedances of crystal circuits)		−10 db
Receiver Noise Level	−125 db	
Crystal Noise Factor	+ 6 db	
	−119 db	−81.5 db
RF S/N Ratio		37.5 db
Improvement Due to Wideband F-M		+12 db
Effective S/N Ratio (RMS)		+49.5 db
For a television signal:		
Ratio of Peak Signal Voltage to RMS Noise Voltage		+58.5 db
Further Improvements:		
(Use of two 8-ft antennas instead of one 8-ft and one 4-ft antenna)		+ 6.0 db
(Elimination of RG-17/U cables)		+ 8.0 db
Max S/N Ratio		72.5 db

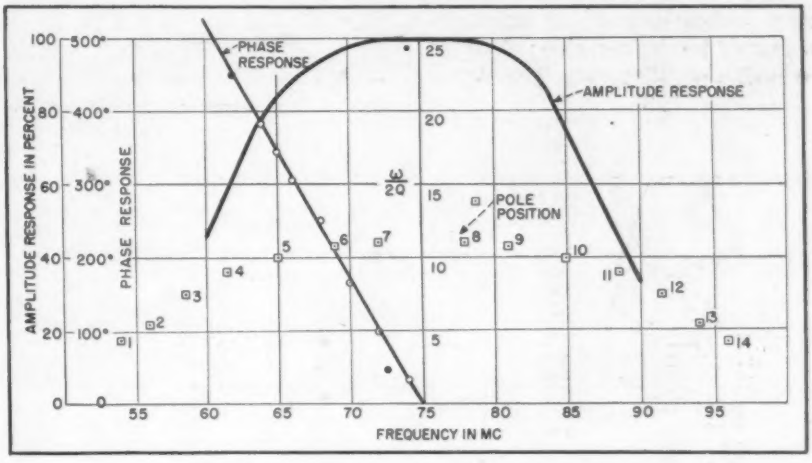


FIG. 8—Receiver i-f amplifier response curve

Operating Characteristics

The system described has no operating controls other than an initial deviation adjusting control. In fact, no additional controls have been found necessary because of the inclusion in the equipment of amplifiers of adequate bandwidth. With a d-c maximum carrier swing of 13 mc, only the first-order sidebands of the f-m signal are transmitted when they occur at the limits of carrier swing. At the high deviation ratio employed, this condition is satisfactory. The amplitude response is controlled throughout the system, while special attention has been paid to the phase response of the amplifiers. For single link pickups a signal-to-noise ratio of 50 db is obtainable at a range of 30 miles provided that no more than a reasonable length of flexible antenna cable is used. System performance data is given in an accompanying table.

The performance of the system in the presence of multipath signals is also good. Under test conditions, with signal levels below normal levels, unique patterns resembling grained wood patterns may be observed, in which the change of picture shading due to the echo will be related to the frequency shift of the carrier during the time interval equal to the difference in the propagation times over the two signal paths. The change of shading is most pronounced following a sharp signal change in the picture pattern. Under normal operating conditions, but in the presence of an echo signal of approximately 5 percent of the strength of the principal signal, essentially complete suppression of the echo is achieved and performance is superior to that of an amplitude-modulated system under equivalent conditions.

chanical support for the grid plane. The grid plane is excited at the i-f frequency. Contact from the i-f final amplifier to the grid plane is provided by a rod which lies in the equipotential plane within the cavity. The capacitance of the grid plane is resonated with the inductor *L*, which is actually within the cavity, the d-c lead being brought out through a feed-through bypass capacitor. Thus the cathodes of the output tubes are driven in push-pull by a balanced r-f carrier signal, while the grids are driven in parallel by the frequency-modulated i-f signal. High-level signals are applied to both cathode and grid circuits, and the tubes are biased by grid current to approximately three times normal cutoff.

The plate cavity is tuned by slug tuners to either the sum or the difference frequency of the two input signals. The r-f output, comprising a frequency-modulated carrier having a deviation equal in megacycles to that of the i-f signal, is obtained through a coupling loop. The output cavity is loaded to a bandwidth in excess of 20 megacycles. Normal operating conditions for this stage are approximately as follows: B voltage, 700 volts; plate current 0.060 amp per tube; grid bias, 30 volts (due equally to carrier and i-f drive); carrier frequency approximately 1,240 mc; i-f drive frequency, 105 to 125 mc; output frequency, 1,345 to 1,365 mc; power output, in excess of 25 watts; carrier-frequency output (without additional filters), about 35 db below output signal.

Receiver Circuit

The receiver circuits (Fig. 1) are all conventional or similar to those of the transmitter, except that the i-f amplifier consists of 12 stagger-tuned stages. Its polar diagram is shown in Fig. 8. Additional poles are required for input and output coupling networks. Single-tuned stages were used throughout be-

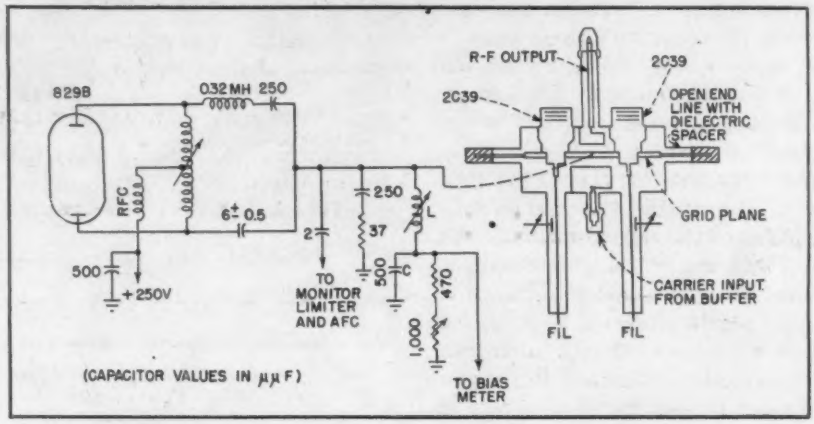


FIG. 7—Heterodyne r-f output stage of the television relay equipment, including part of the preceding i-f amplifier

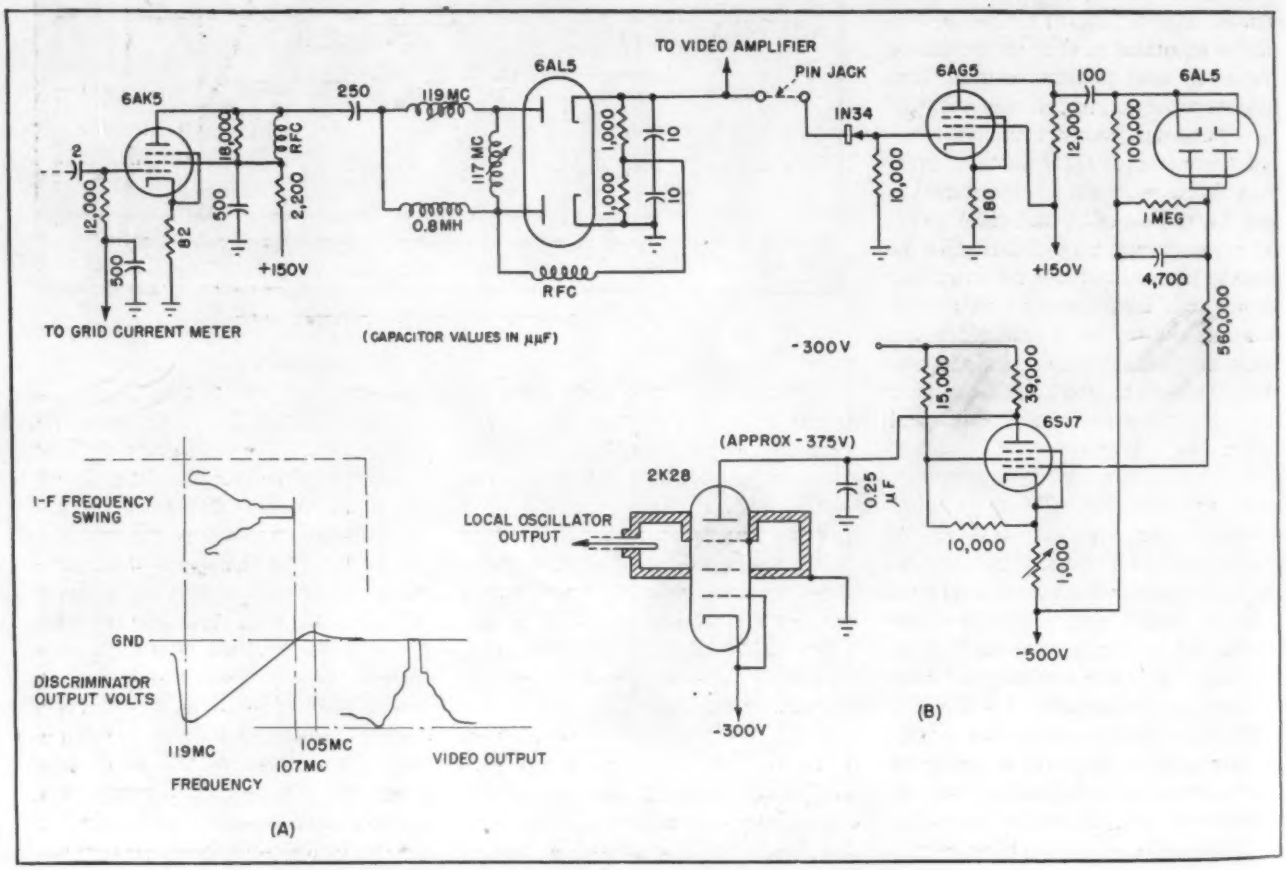


FIG. 6—Discriminator circuit employed in the system

PRODUCTION TESTING

Power with which to operate instruments at any one of 21 calibration speeds is obtained from a tuning-fork oscillator, electronic amplifiers, synchronous motors and unique electromagnetic generators. Remote control of test frequencies is available to each operator

By HERBERT F. STORM*

Control Engineering Division
General Electric Co.
Schenectady, N. Y.

THE PURPOSE of aircraft tachometers is to indicate the rotational speed of the engines. The remoteness of the engines from the instrument panel generally makes mechanical means of transmission impractical and calls for the application of electrical telemetering techniques.

The telemetering system usually consists of a synchronous, three-phase generator which is mounted on and driven directly by the aircraft engine, and a synchronous three-phase motor located in the indicator instrument on the instrument board and energized by the tachometer generator.[1, 2] The instrument motor rotates an assembly of permanent magnets which produce an electromagnetic torque in an aluminum alloy disc. The disc is displaced by the electromagnetic torque against the restraining torque of a spring with linear elongation characteristic. Therefore, by coupling a pointer to the disc, a deflection can be obtained that is proportional to the speed of the aircraft engine.

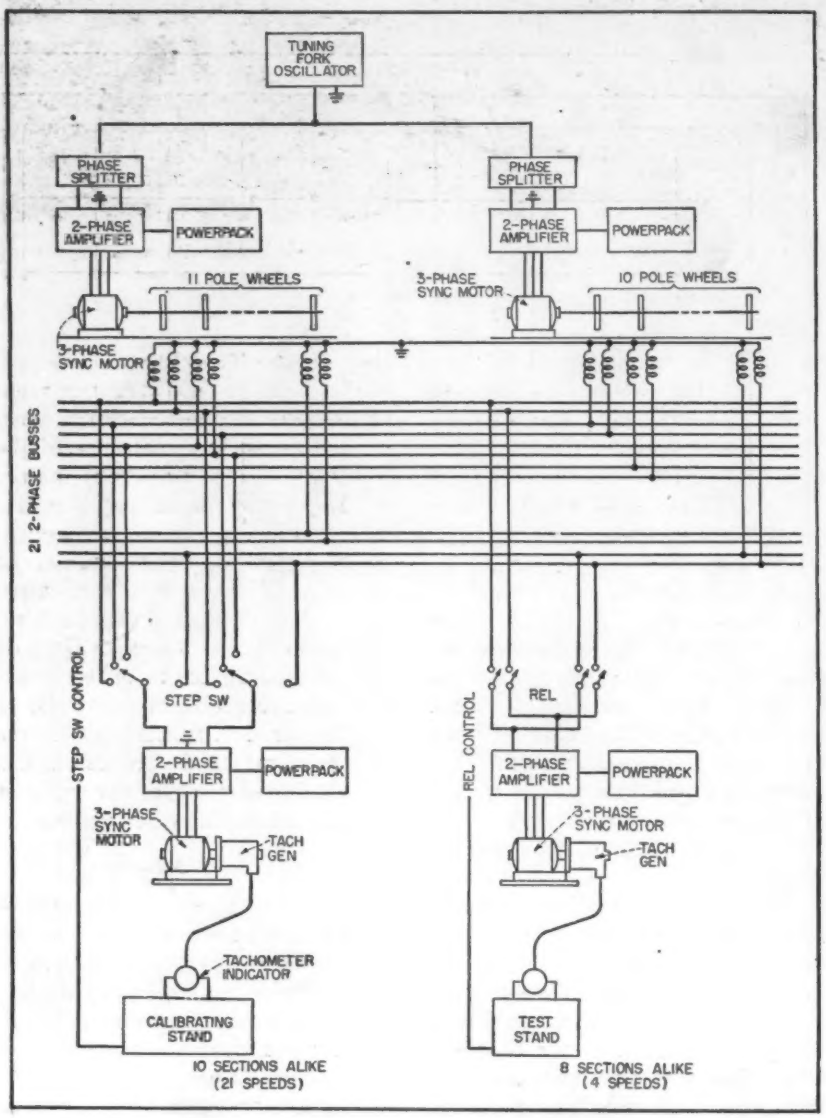


FIG. 1—Block diagram of the testing system

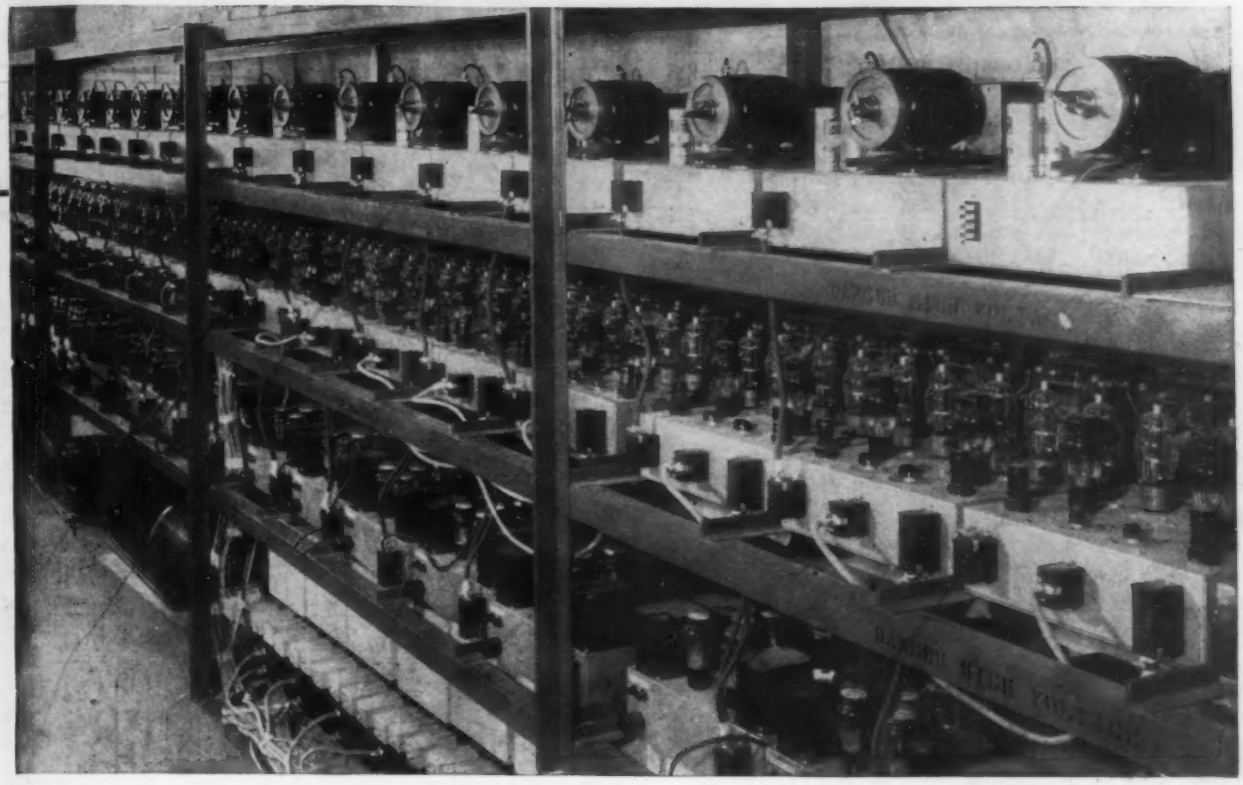
The indicator instruments are assembled from interchangeable subassemblies. Each subassembly must be tested before it is placed on the main assembly line. Finally, the fully assembled instrument is tested. Tests include exposure to vibration, various angular positions in space, temperature as low as −55 C and as high as 70 C. These tests must be conducted at various predetermined speeds and at narrow tolerances.

After the instrument has passed through all the preliminary tests, it is calibrated at a speed of 3,000 rpm, corresponding to two-thirds full scale, by partially demagnetizing the rotating permanent magnets. The calibration is then checked for increasing and decreasing speeds. While some tests are required to be made at only four predetermined speeds, other tests require as many as twenty-one predetermined speeds.

The requirements for a tachometer testing system handling large

* The testing equipment described was developed, built, and operated by the Sunbeam Corp., Chicago, with which the author was formerly affiliated.

OF TACHOMETERS



Equipment for the production testing of aircraft tachometers. Pole wheels are on the floor, in the background, with frequency-selector relays and stepping switches in the foreground. Powerpacks are on the first shelf, two-phase amplifiers on the second and synchronous motors driving tachometer generators on the third

quantities of instruments at high accuracies may be stated as follows:

(1) Selection of the predetermined speeds must be a simple operation.

(2) Test speeds must be of an accuracy exceeding the accuracy of the instrument under test.

(3) It must be possible to operate simultaneously a multitude of testing stands.

(4) A test going on at one test stand must not interfere with tests being conducted simultaneously at other test stands.

(5) Test equipment must stand up under almost continuous use.

Basic Solution

In Fig. 1 a tuning fork oscillator of an accuracy of 0.001 percent and 50 cycles per second is used as a standard frequency reference.[3] The single-phase output of the tuning fork oscillator is fed into two phase splitters consisting of resistance-capacitance networks which split the oscillator voltage into two components electrically approximately 90 degrees apart. The two voltages are applied to the inputs of two two-phase amplifiers. The two output transformers of the two-phase amplifiers are in Scott connection, resulting in three-phase power output.[4] This three-phase power is used for energizing two synchronous motors driving a total of 21 two-phase generators (called pole wheels) which produce voltages at 21 different frequencies, corresponding to the 21 different speeds at which the indicator instrument is to be operated under test.

The voltages generated by the 21 pole wheels are routed to a bus system from which they can be picked up by rotary switches or relays and fed into two-phase amplifiers. These two-phase amplifiers are identical with those used for energizing the synchronous motors which drive the pole wheels. Their three-phase output is used to energize synchronous motors driving standard tachometer generators. Because of the application of synchronous motors and generators all the way through, the accuracy at which the instrument motor will run equals the accuracy of the tuning fork oscillator. The output of the tachometer generator is wired to the test or calibrating stands of the indicator instruments. The test stands are equipped with means for the remote control of the associated amplifier and for the selection of any speed necessary for testing.

Two-Phase Amplifiers

Both phases are independently amplified throughout the system, but the output sides of the output transformers in each two-phase amplifier are connected in Scott transformation in order to obtain a three-phase output.

The first stage of each amplifier

used for the amplification of the small voltages obtained from the pole wheels (or from the phase splitters) operates on an input signal of between 0.1 and 1 volt. These rather small voltages require high-gain amplification which is obtained from a 6SJ7 tube in pentode connection as shown in Fig. 2. The frequency range is 8⅓ to 75 cycles per second. Because of the low frequency, unusually large capacitance values have to be chosen for the bypass capacitors shunting the cathode bias resistor and the screen resistor, as well as for the coupling capacitor to the following stage.

The second stage uses a 6L6G tube, connected as a class-A1 amplifier to provide driving power for the final stage. The final stage consists of a push-pull amplifier in class-AB, connection, using 807 tubes. It was necessary to connect radio-frequency chokes in the plate and screen grid leads in order to suppress parasitic oscillation.

The output transformers were especially designed in order to permit operation at very low frequencies and also to provide the correct winding ratio for Scott transformation. With variable speeds of the synchronous motor (energized from the amplifier), the load resistance of the motor reflected between the plates of the 807's also varies. At the higher speeds of the synchronous motor, where relatively large amounts of power are required for pulling into synchronism, rematching of the output impedance becomes necessary. For this purpose additional taps at the output transformer are provided and these are automatically switched by the speed selector.

The synchronous motor driven by the amplifier is rated ⅓-horsepower, 220 volts, three-phase, 1,500 rpm at 50 cycles. Power-factor correction capacitors adjusted for full compensation at full load were used to unburden the amplifier from carrying inductive reactive power.

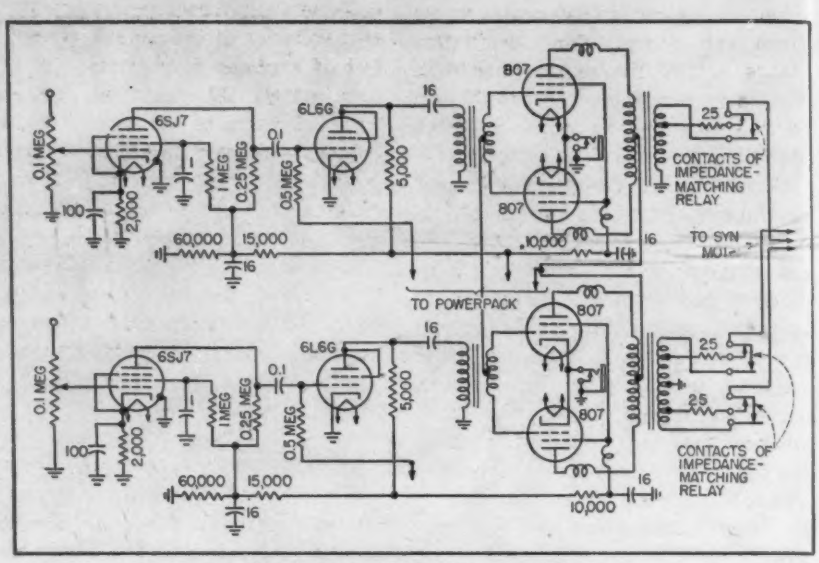


FIG. 2—Typical two-phase amplifier

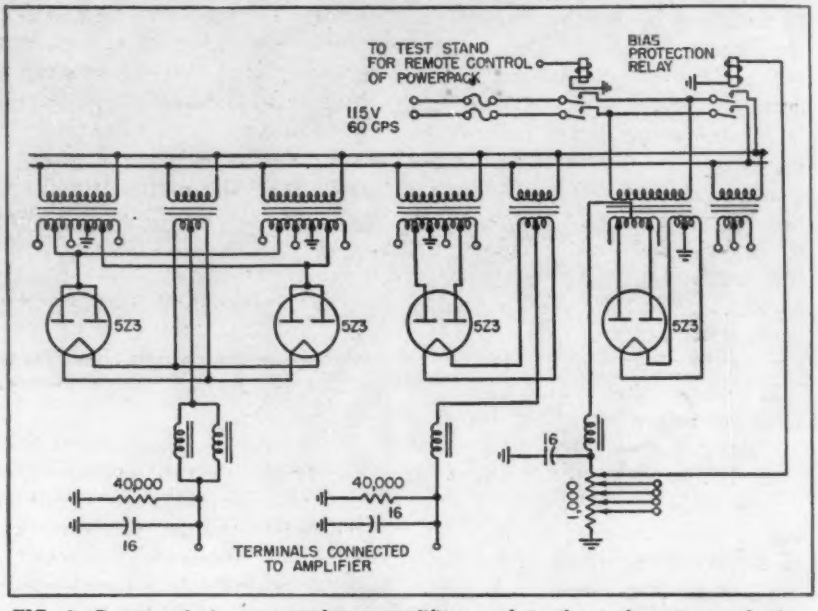


FIG. 3—Powerpack for a two-phase amplifier used in the tachometer production testing setup

Powerpack

Each amplifier has a powerpack, as shown in Fig. 3. Two 5Z3 tubes are used to provide the plate power for the two 807 push-pull amplifiers. Another rectifier produces the plate power for the first and second stages and the various screen currents. A third rectifier is used for obtaining the bias voltages for the second and third stages. The powerpack is remotely controlled from the test stand by means of a relay whose contacts control the 115-volt power supply. In order to protect the amplifier against overload in case of loss of bias, a protection relay is energized from the bias voltage. The contacts of this relay are in series with the 115-volt supply. In case of bias voltage failure, this relay becomes de-energized, opens its contacts, and thus disconnects the rectifiers from the 115-volt, 60-cycle power supply.

Figure 4 shows, from right to left, the powerpack, the amplifier, and the synchronous motor-generator section. The relay between the two output transformers, visible on the amplifier chassis, is the automatic impedance rematching relay. The two knobs at the front end of the amplifier chassis control the potentiometers for the input to the first amplifier stages. A tuned flywheel serves to subdue torsional oscillations of the synchronous motor.

Pole Wheels

The two synchronous motors shown in the upper section of the block diagram (Fig. 1), have four poles and hence rotate at 1,500 rpm

when energized by 50-cycle power from the tuning fork oscillator. Gears reduce the motor speeds to 100 rpm on one machine shaft and to 200 rpm on the other machine shaft.

A number of discs are mounted on the two shafts, as shown in Fig. 5. Various numbers of teeth are cut into the discs. Each of these discs or pole-wheels is straddled by one pair of pickup coils. Each pickup coil has two windings. One winding is energized by d-c and serves to magnetize the pole-wheel, whereas the other is used to pick up the a-c voltage induced in it by the variable magnetic flux, caused by the teeth and slots in the pole wheels.

If a pole wheel has, for instance, 36 teeth and is rotating at 100 rpm. the frequency picked up by the coils will be 36 x 100 = 3,600 cycles per minute or 60 cycles per second. This is the frequency for a tachometer generator and instrument motor running at 1,800 rpm. Since the tachometer generator is coupled to the cam shaft of the aircraft engine, the engine runs twice as fast, namely, 3,600 rpm. Consequently, the indicator will also indicate 3,600 rpm as the speed.

It follows that the number of teeth per pole wheel of the 100-rpm machine has to be 1/100 of the speed to be indicated by the instrument. On the 200-rpm machine the number of teeth per pole wheel has to be 1/200 of the speed to be indicated by the instrument.

The application of two pickup coils per pole wheel serves to obtain two voltages of the same frequency, but of a phase displacement of approximately 90 electrical degrees. Thus 21 pairs of voltages are generated, each pair having a different frequency corresponding to the 21 different speeds to be obtained for the instrument motor.

In order to minimize magnetic stray fields and at the same time to provide mechanical protection, guards made from soft iron are placed over the pole wheels.

Test Stands

In order to test tachometers in production 18 test stands are required. Eight test stands are operated at four predetermined speeds, whereas the remaining ten require 21 predetermined speeds. Besides obtaining 21 speeds, it is necessary that these speeds can be obtained in increasing and decreasing sequence.

In order to select the frequencies allocated to the various speeds, relays and stepping switches were chosen which are remotely controlled from the test stands. For the four-speed test stands, relays were used for frequency selectors, whereas in the case of the 21 speed calibrating stands, rotary switches were applied.

Each four-speed test stand has a selector switch to energize any of the four selector relays which are assigned to the specific test stand. Contacts of these selector relays establish electrical connections between one of the 21 different frequencies from the bus system and the input of the two-phase amplifier which is allocated to the test stand under consideration. The powerpack belonging to this amplifier is turned on by remote control from the test stand. By operating the selector switch for the selection of a given speed, the corresponding selector relay energizes the two-phase amplifier with the correct frequency. This amplifier energizes a three-phase synchronous motor which belongs to the test stand under consideration, and makes it run at the desired rotational speed. A tachometer generator coupled to the foregoing synchronous motor provides the energy to be used for operating the instrument motor in the instrument under test.

In order to provide 21 speeds in increasing and decreasing sequence, one rotary stepping switch was assigned to every one of the ten calibrating stands. This switch is of a standard telephone type, having 50 positions and four levels. Two levels of the rotary switch connect the standard-frequency busses to the input of a two-phase amplifier of which one amplifier (with powerpack) is assigned to each calibrating stand. The frequencies are connected to the rotary switch in such a way that the brushes will connect the frequencies in sequence, increasing from 500 rpm to 4,400 rpm and then declining from 4,400 rpm down to 500 rpm. The third level of the rotary switch energizes indicating lamps located at the calibrating stand, identifying the

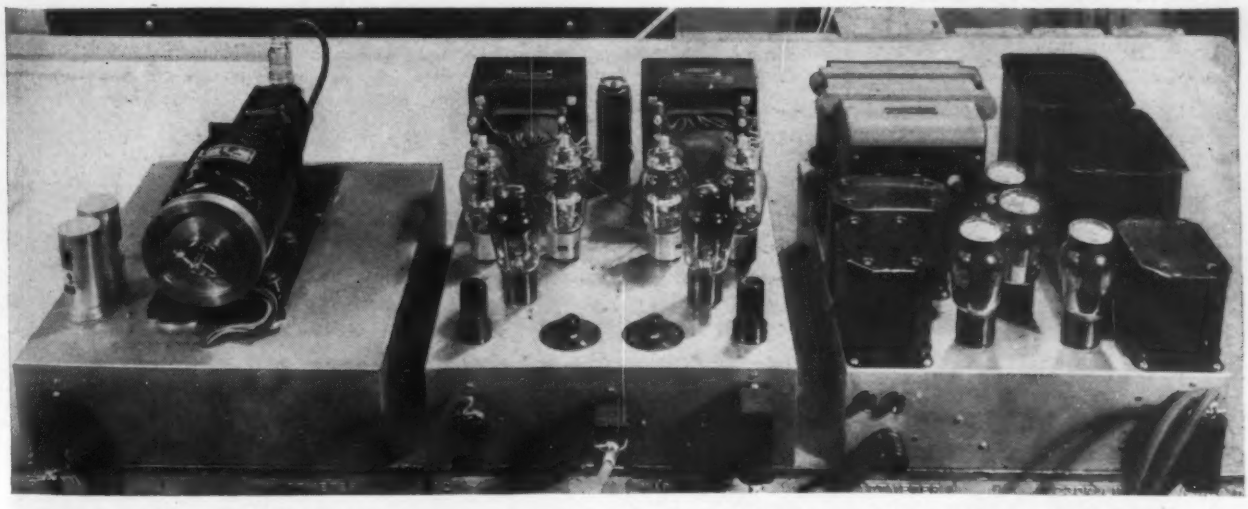
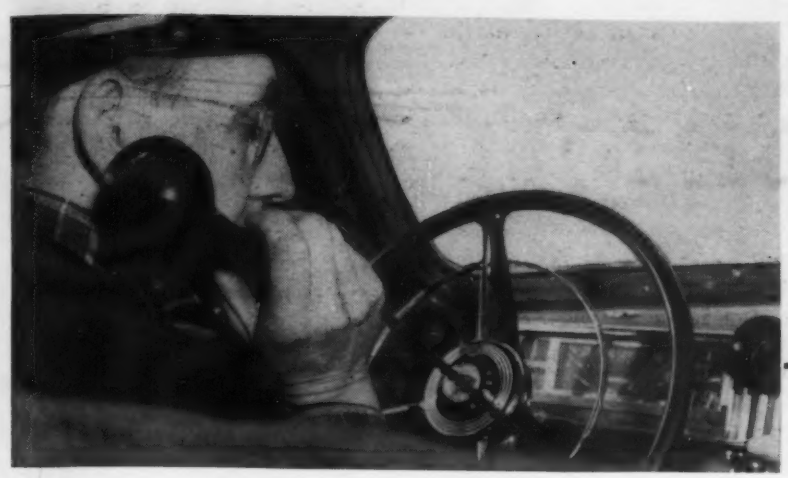


FIG. 4—From left to right: synchronous motor tachometer generator chassis, two-phase amplifier, and powerpack

RADIO DISPATCHING for Taxicabs



Companies using two-way radiotelephone equipment in newly opened 157-megacycle region find it pays for itself in a short time. A system using commercially available f-m transmitters and receivers is described

TWO-WAY radio between dispatcher and cabs in a taxi fleet furnishes an important new market for communications equipment, effects important economies in fleet operation, and provides better, cheaper service for the riding public.

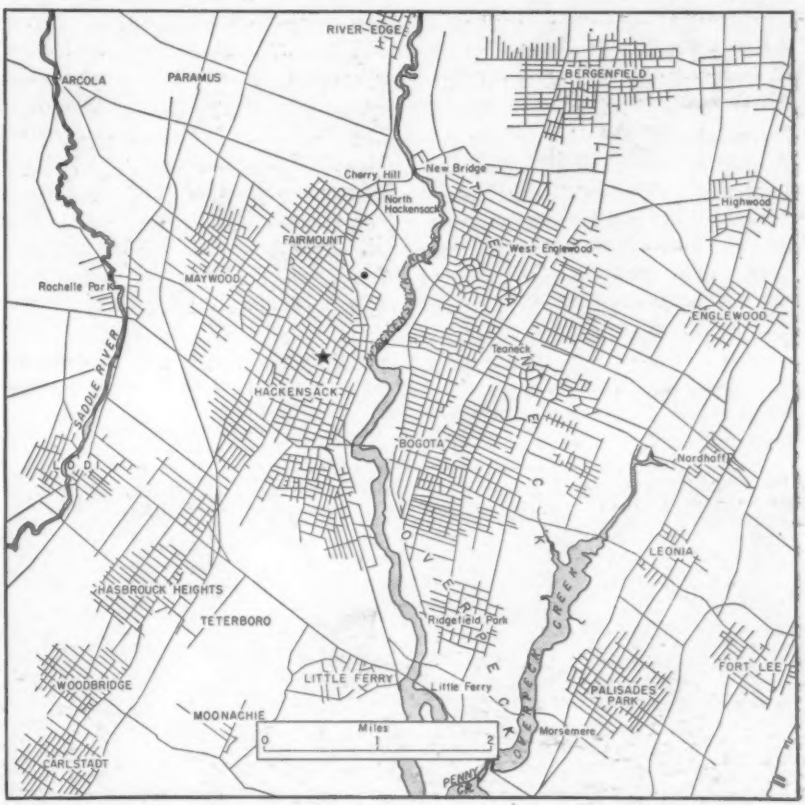
A study of several recent installations now operating under experimental licenses indicates a need for overall engineering of systems operating in any given area, an awareness on the part of FCC of the rapidly growing problem of frequency assignments, and, particularly in the initial stages, a strong spirit of good will and active cooperation among users of the new technique.

Potential users must consider the specific sort of taxi service they render and tailor their demands upon equipment manufacturers accordingly.

Representative System

One particular set of operational problems is faced by the Hackensack Taxi Service, covering the area in and around Hackensack, Bogota and Teaneck, New Jersey. Meticulous records have always been kept, so that it is easy to assess gains or losses with any innovation.

Since installation of the two-way radio system, fares have averaged 6 percent more for the same fleet, with the number of completed trips



Map showing area of taxi operations covered by 15-watt transmitters. Location of fixed station transmitting and receiving antenna about 90 feet above sea level is indicated by star. Some areas served are behind elevations exceeding that of this antenna

speed selected by the rotary switch. The fourth level is reserved for the control of the selector switch.

If a test should be made in which every speed is needed for increasing as well as decreasing values, the operator pushes a step-button on the panel of the calibration stand shown in Fig. 6. If the rotary switch is in its home position, no voltages are fed into the input of the amplifier and the synchronous motor is standing still. As soon as the operator actuates the pushbutton, the rotary switch will step into a position where the amplifier input is connected to one of the 21 frequencies, resulting in the lowest speed (500 rpm.). If the operator wants, at this time, to go to the next speed (600 rpm), all he has to do is to again push the same pushbutton. The rotary switch will now make one more step, connecting the amplifier to a frequency corresponding to 600 rpm. Every time the operator pushes the button the next higher speed will be obtained, until the top speed of 4,400 rpm is reached. After that the speed will be reduced, step by step, every time the operator pushes the button.

In the majority of tests, however, certain speeds can be skipped. In order to maintain the same simple operation and yet obtain automatic skipping, a two-position selector switch was provided on the calibrating stand. If this selector switch is switched into *local* position, every one of the 21 speeds is obtained. If, however, this selector switch is turned into *express* position, voltages are supplied to certain contacts on the control level of the rotary switch. Any time the brush of the control level finds a contact which is energized by the selector switch it will energize its electromagnet, resulting in a further step of the rotary switch. Thus, if the operator wants to obtain the next speed, all he does is to push the *step* pushbutton once, as usual.

If it is desired to test an instrument at only one speed, for instance 3,000 rpm, it is not necessary to use the *step* pushbutton to step the rotary switch by multiple operation of this pushbutton until the speed of 3,000 rpm is reached. In order to avoid such loss of time another pushbutton, *up to 4,400 rpm*, is provided which when pressed, makes the rotary switch step up automatically. As soon as the desired speed is obtained, readily visible from the indicating lamps, the pushbutton is released and the rotary switch remains in the desired position.

In order to return the rotary switch to zero from any position, it is not necessary to push the *step* pushbutton until the rotary switch is brought back step by step to the zero position. A special pushbutton marked *back to zero* is provided which energizes all contacts of the control level except the home contact. The rotary switch then runs into its home position within one or two seconds, depending on the contact point at which the rotary switch was standing before this pushbutton was operated.

In the calibrating stand pictured a dual tachometer indicator is under test. The changeover switch on the left side of the panel permits the energization of either or both instruments. The two a-c electromagnets surrounding the instruments serve to partially demagnetize the permanent magnets for the purpose of establishing one point of the calibration. By operating the changeover switch the electromagnet belonging to the indicator motor under calibration becomes energized. The current in this electromagnet is controlled by means of a variable transformer. The front panel of the calibrating stand shows 21 indicating lamps corresponding to the 21 available speeds. The pushbuttons for the control of the rotary switch and the *local-express* selector are shown in the lower section of the panel.

FIG. 6—Typical tachometer calibrating stand at which an operator remotely controls test frequencies and adjusts instruments by rotating the demagnetizing control wheel at the right

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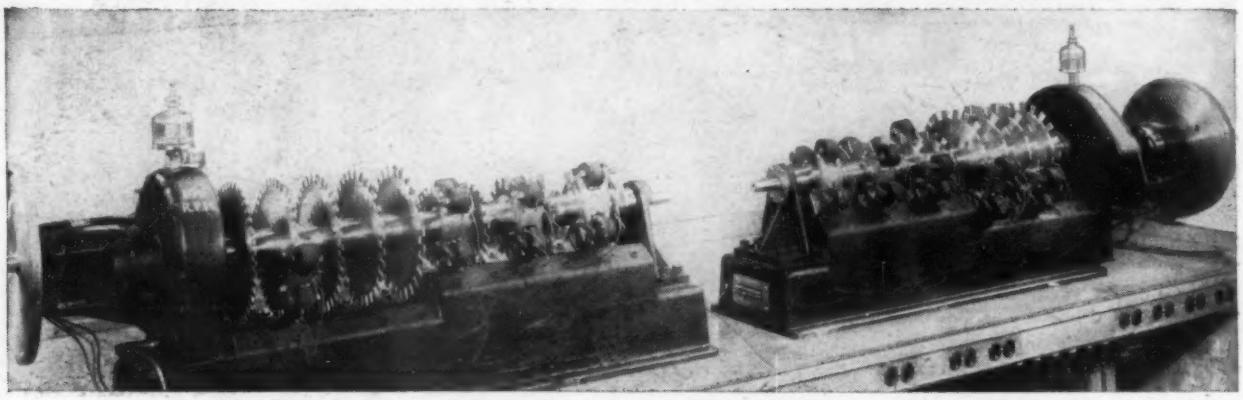
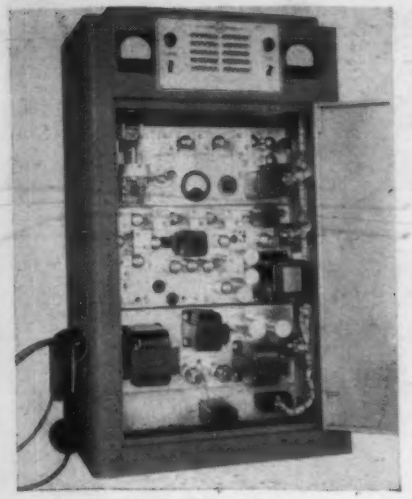


FIG. 5—These two pole wheel arrangements electromagnetically generate 21 tuning-fork-controlled test frequencies



Fixed station transmitter-receiver located near foot of antenna and a half mile from dispatchers office. From top to bottom, chassis contain transmitter, receiver, and power supply

Here the incoming subscribers' telephone lines, radio control unit and microphone are located. The antenna used for transmitting and receiving is atop a 60-foot mast mounted on a one-story building used for repairs, maintenance and garaging, about half a mile from the dispatchers' office. The compact transmitter-receiver unit, itself locked, is fastened to the wall of a locked room in the garage and is connected to the control equipment by two pairs of wires furnished by the telephone company. One line is used for audio signals, incoming and outgoing, while the other serves to operate the send-receive switching mechanism built into the locked unit.

A complete log of all transmissions is kept by the dispatcher on duty, who is required to hold a restricted radiotelephone operator permit. The individual taxi drivers are not required to be licensed for radio operation inasmuch as their equipment is tamper-proof. One experienced technician, on call 24 hours a day, is the only person allowed to adjust the transmitting equipment and he holds a Radiotelephone License, First Class, as required by the FCC.

Fixed Station Details

The fixed station equipment is remotely controlled by the dispatcher. It comprises a phase-shift f-m transmitter and a receiver. Provision is made to switch the transmission line from the antenna to either unit as the wire line is connected to receiver or transmitter. The bandwidth of the antenna has been designed to provide adequate gain for both fixed and mobile frequencies. The circuit elements making up this equipment are shown as a block diagram in Fig. 1.

The phase-shift transmitting system shown in Fig. 1A provides a frequency-modulated signal with sufficient deviation to reduce noise and allow reasonable audio quality. A deviation of 20 kc each side of the carrier frequency (as contrasted with the broadcast standard of 75 kc) is adequate to provide an overall audio response that is essentially flat from 350 to 5,000 cycles. At the same time, stringent legal and practical problems of frequency stability are solved by using this circuit.

The number of frequency multiplications (96) is readily accomplished with 5 tubes. Nominal power output is 15 watts, but performance of the system can later be enhanced by the use of a higher-gain antenna or a more favorable antenna height or location.

The receiver is crystal controlled in order to insure optimum signals from unattended equipment. The block diagram of Fig. 1B shows the layout of circuit elements. A double-conversion superheterodyne makes use of a single crystal operating at 9.03 megacycles for both local oscillator frequencies. The double i-f system gives good bandpass characteristics and a favorable image ratio. A squelch circuit can be switched in or out to quiet the audio output of the receiver during the period when no signal is being received.

Since the transmitter-receiver operates on 115 volts and power consumption varies between 125 and 320 watts, no special wiring is necessary.

Mobile Stations

Circuitwise, the mobile equipment is identical with that employed in the fixed station, but is differently packaged. A loudspeaker is normally operative in the taxi, but the receiver of a telephone handset can be used for conversations once communication is established. A switch on the handset operates a relay to shift the antenna connection from receiver to transmitter when the cab operator wishes to talk back. The antenna itself is a quarter-wave whip mounted through the roof of the cab and works against the metal roof as a ground. Power is taken from the car storage battery and the total standby power drain is about 10 amperes at 6 volts. An additional 23 amperes is required during periods of transmission from the cab.

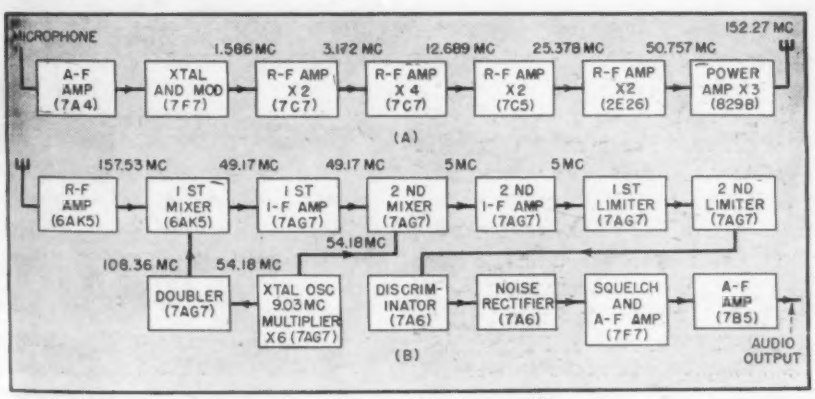


FIG. 1—Block diagram of Hackensack system circuit elements used in both fixed and mobile transmitters (A) and receivers (B). A single crystal furnishes conversion frequencies for the double-detection superheterodyne receiver

Acknowledgment

Assistance by Harry G. Remsen, proprietor of the Hackensack Taxi Service, and officials of the Link Radio Corp., in the preparation of this article is gratefully acknowledged.—A.A.McK.

per hour correspondingly increased. On the basis of these figures, it is anticipated that the whole radio installation will pay for itself in ten months. "Over the meter" charges on out-of-town calls have been dropped since radio dispatching was installed. This means that the customer who formerly paid a meter charge from the taxi terminal to his home, as well as the regular home-to-destination charge and twenty-five cents in addition, now pays only for the actual mileage from home to destination. Radio dispatching eliminates the unproductive return mileage formerly run up by the cab on such calls.

The type of community served dictates the sort of dispatching service needed. Hackensack and its suburbs are typical of many small cities everywhere that do a "telephone" rather than a "pickup" taxi business. Because the majority of users initiate requests for service by telephone, as early as 1924 a telephone call box dispatching system was installed that increased earnings 20 percent and also improved service. The telephones were available to the public as well as to reporting drivers. A portion of the telephone system has been retained as a service to customers, but in no way competes with the radio dispatching system. In fact, the radio system has increased the utility of the telephone. All instruments are connected in parallel on one line so that when a customer fails to hang up the system goes dead. Now the dispatcher can send the nearest car to the phone last used with instructions to hang up the receiver!

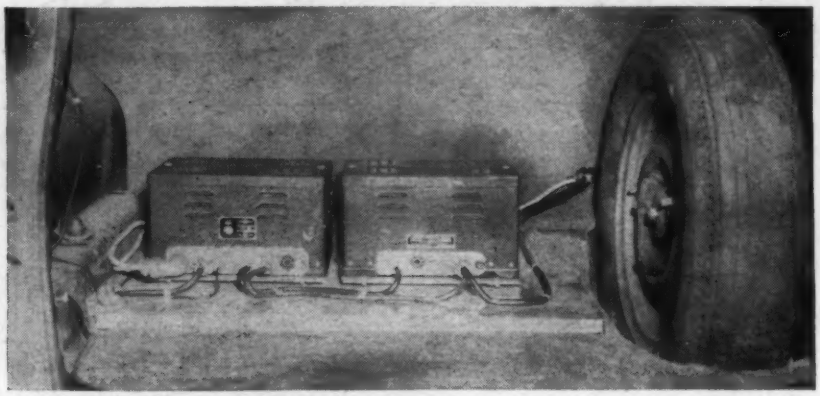
Dispatchers' desk showing dual telephone positions for incoming calls, radio microphone, and remote control unit that is operated by foot switch

It is the feeling of the company that the type of dispatching operation best suited to the situation is now in use. The number of cabs (11 at present) does not require a selective calling system of the sort that may be desirable in a larger fleet, and in fact, would slow down operations under the present system without adding to its serviceability. While no sort of lockout system is now in use, again because of the relative smallness of the fleet, it may be considered desirable to install a simple system as business expands.

Because all the cabs share pickup and telephone business equally, it has been desirable to equip each cab with two-way radio. Present experiments in larger cities may possibly show that a law of diminishing returns begins to operate before a whole fleet is radio equipped.

At the present time, 11 separate companies centered in as many communities of northern New Jersey are operating two-way radio systems with all dispatchers' transmitters operating on the experimental frequency of 152.27 megacycles and all cars on another experimental frequency of 157.53 mc, assigned to taxicab service over the whole country.

Each installation was a separate job, with antennas generally erected in locations dictated by conditions of expediency. For this reason signals from several dispatchers can be heard in any cab. Operations are sometimes difficult and would have been next to impossible without the formation of an association of the various owners, who have standardized calling procedures and assigned numbers with which the individual number of each cab in a given fleet is prefixed. For instance, Hackensack cabs use the dispatching numbers 9-1 through 9-11. Call letters assigned by FCC to the dispatcher, W2XKG, and the cars, W2XKH, are employed only as often as legal requirements demand.



Mobile transmitter (left) and receiver (right), mounted in rear deck of taxi

Equipment Installation

Physically, the present Hackensack radio plant has been adapted to existing facilities. The dispatchers' office is located in the center of the city near rail and bus terminals.

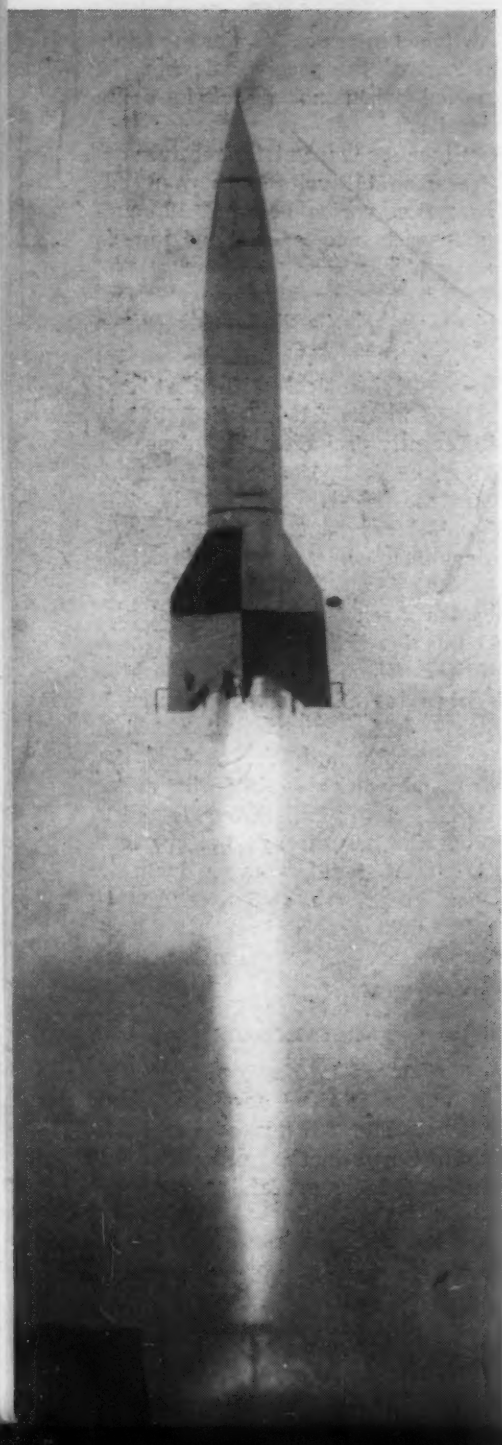
TELEMETERING From V-2 Rockets

Time-modulated pulse system in nose of rocket samples successively up to 23 instruments and transmits readings to ground station over 1,000-mc radio link using 2C43 disk-seal tube as oscillator. Airborne circuits are given here; Part II will cover ground circuits

By V. L. HEEREN
C. H. HOEPPNER* J. R. KAUKE
S. W. LICHTMAN and P. R. SHIFFLETT

Office of Research and Inventions, Naval Research Laboratory, Washington, D. C.

** Now with Glenn L. Martin Co., Electronics Lab, Baltimore, Md.*



V-2 rocket taking off at White Sands, New Mexico, with radio telemetering equipment in nose. The AAF program calls for firing a total of 50 of these guided missiles

Part I

ONE of the most important problems which must be solved in connection with the use of a rocket as a vehicle for upper-atmosphere research is that of making available to the observer information obtained at the rocket during flight. Radio telemetering equipment designed by the Rocket Sonde Research Section of the Naval Research Laboratory has been employed for this purpose during all of the V-2 firings at White Sands, New Mexico.

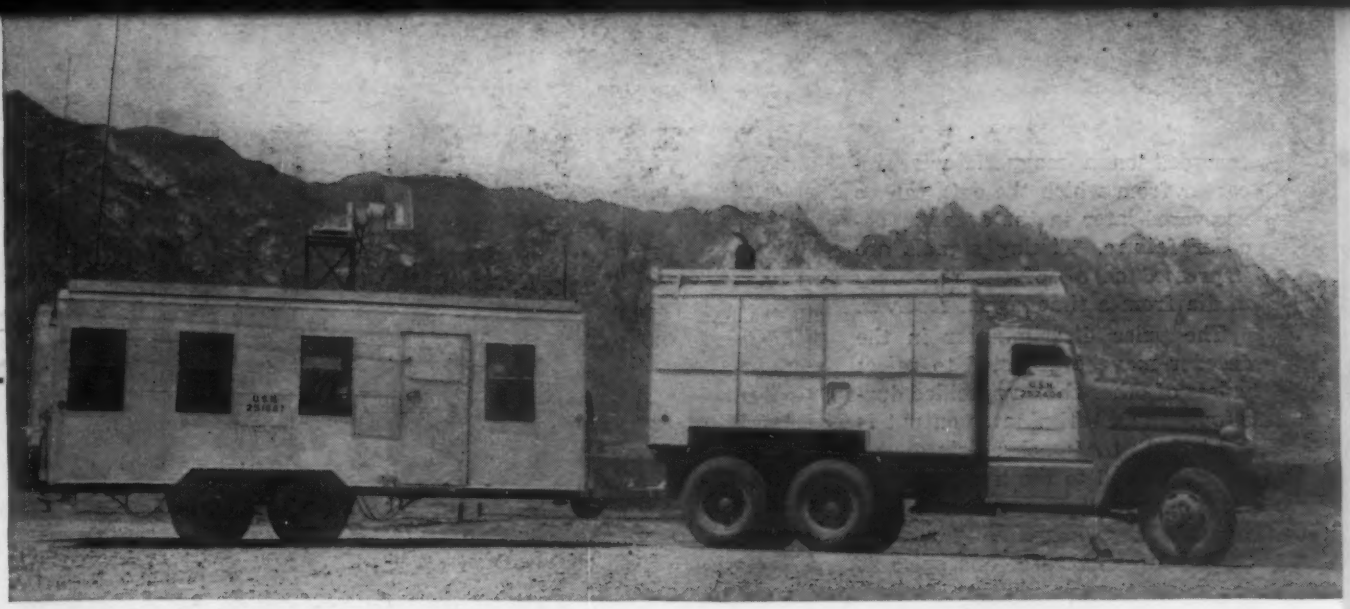
Typical of the basic research data telemetered by the system are temperatures and pressures in the upper atmosphere, various characteristics of the primary cosmic radiation, and properties of the ionosphere. For studies of rocket performance, data are telemetered on such quantities as speed, rocket acceleration and altitude, skin temperatures at various critical points, and motion of the control fins.

The system was designed to telemeter, by means of independent time channels, as many as twenty-three separate quantities by successively sampling a corresponding number of data voltages obtained from instrumentation installed in the rocket. The sampled voltages are converted to a form suitable for radio transmission, radioed to a ground station, reconverted to their original form, and recorded.

Time-Modulated Pulse System

To obtain reliable telemetering over ranges in excess of 100 miles with limited allowances for size and weight of the rocket-borne equipment, a time-modulated pulse system was chosen. The pulse system delivers a higher peak power with a lower average power consumption and occupies less space than a comparable continuous-carrier system. The system used in the V-2 operates at about 1,000 megacycles, a frequency which is high enough to penetrate the ionosphere and which at the same time is clear of other frequencies used in the flights.

The data voltages are converted into time intervals, defined by voltage pulses, corresponding in length to the magnitude of the data voltages. The data voltages are sam-



Mobile telemetering ground station. The trailer carries a 1,000-mc receiver, a decoder, recording equipment, monitoring and test equipment, communication receivers and transmitters, and timing mechanisms, while truck contains 25-kw power generator

pled in a specific order and are used to generate a series of pulses, the time intervals between which measure the sampled data voltages. The intervals maintain the same time sequence as the sampled voltages, the pulse marking the end of one interval serving as the initial pulse of the succeeding interval.

A complete sampling of all data voltages is used to form such a group of time intervals periodically. A master keyer initiates the sampling process at a uniform rate. The distinction between different groups is made possible by allowing for a sufficiently long time between the initial pulses of each group. In this manner, the interval between the last pulse of one group and the first of the next is made to be very much longer than any of the measurement intervals.

Airborne Unit

In Fig. 1 is a block diagram of the airborne unit which converts data voltages into appropriate form and transmits a corresponding radio-frequency signal. A master keyer, which is a freely running multivibrator of constant period, generates the first pulse of each group. This pulse is fed to a channel collector, a circuit common to the outputs of each time channel, and at the same time is used to trigger time channel multivibrator 1.

The multivibrator for each channel is of the self-returning type, the recovery time of which is determined by the corresponding data voltage. The first, upon recovery, delivers a pulse both to the channel collector and to channel 2 multivibrator, which in turn triggers that of the next channel and delivers an output pulse to the collector. The process is repeated in appropriate sequence until all time channels have operated, after which the circuit is quiescent until the master keyer again initiates the sequence. The output pulses delivered to the channel collector by the various multivibrators are fed to a power modulator which in turn pulses the vhf power oscillator, feeding the antenna.

Ground Station

In Fig. 2 is a block diagram of the ground station. which receives, decodes, and records the data. The antenna is trained to follow the airborne radiator by both optical and signal-maximizing techniques. The detected output of the receiver, suitably amplified, is fed into a decoder unit, the purpose of which is to recover the original voltage forms from the time-modulated signals. The original data is then separated into the various channels, displayed on meters, and recorded by various methods.

The use of several different methods of recording provides safeguards against the possibility that the whole record be lost due to the failure of any one method. The principal record is made on a moving strip of photographic paper by means of Hathaway magnetic string oscillographs. Auxiliary records are obtained by photographing the meter panel with a 35-mm movie camera. An oscillographic record is made of the output of the video amplifier with a continuous film camera. The same signal is

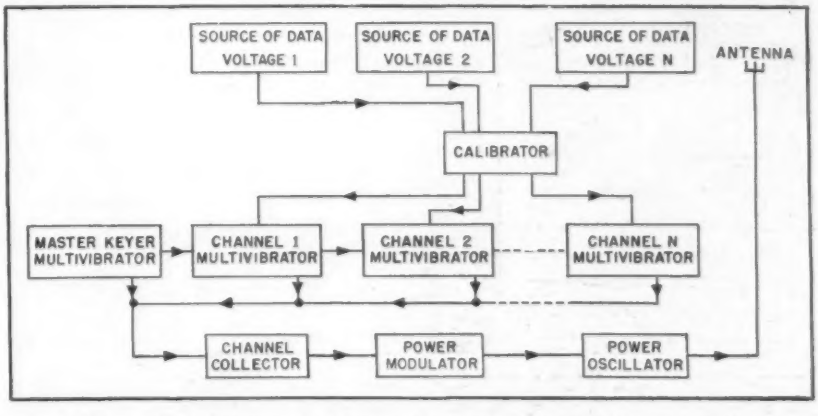
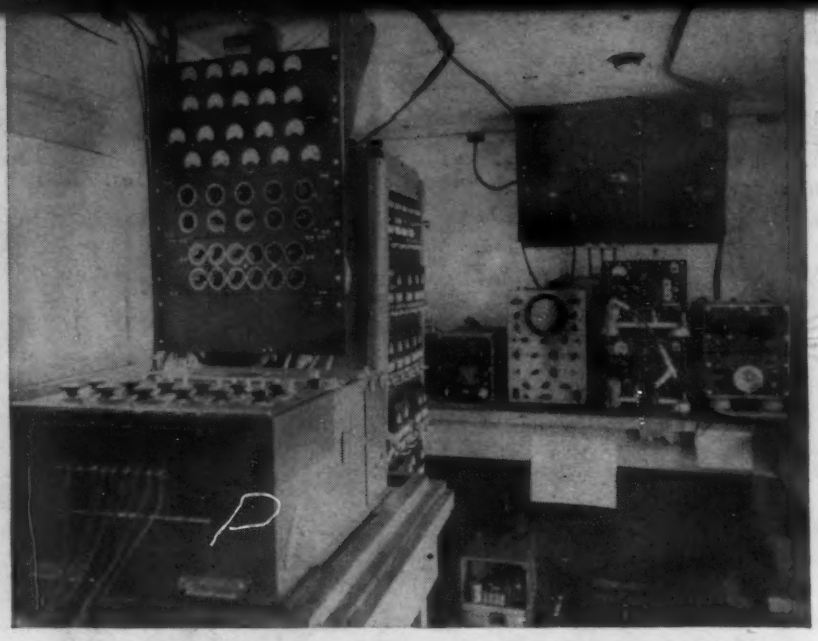


FIG. 1—Block diagram of airborne telemetering unit used in V-2 rockets

recorded on a magnetic wire recorder from which the data can be recovered later in the event of decoder failure. Timing signals are impressed on all of the recording media from a time signal receiver.

The pulse discriminator in the decoder may be adjusted to reject pulses of other than a specified duration. The discriminator output is fed to both the synchronizing pulse generator and to the input of each channel separator via the pulse inverter. The synchronizing generator output consists of one pulse at the start of every group of received pulses, which goes to channel 1 separator, triggering a multivibrator. This multivibrator is returned to its original state by the second pulse of the pulse group now arriving from the inverter. On returning to its original state, separator 1 delivers a pulse which triggers separator 2. The return of separator 2 is effected by the third pulse of the incoming series relayed by the pulse inverter. This action continues, each channel separator triggering the following channel while being itself returned by the signal.

During the conduction period for any channel separator, the corresponding metering circuit is fed a constant voltage, the same for all channels, for a length of time equal to the interval representing the corresponding data voltage. A capacitor is charged thereby to a potential which depends upon the duration of the voltage applied. By suitable circuits, this potential is measured with a vacuum-tube voltmeter, the magnitude being a linear function of original data voltage.



Interior of trailer serving as mobile ground station. At left foreground is a standard 12-channel Hathaway magnetic string oscillograph. Meters above it read individual channel output voltages, and are photographed by a movie camera (not shown) during each test. Upright instrument behind meters and facing right is the decoder. Instruments on table at rear are, left to right, video amplifier, monitoring scope, antenna servo control unit, and timer unit

Calibrator units are placed in the transmitting station to determine any shift in the absolute response of the system. The calibrator periodically breaks the connection from the data voltage source to the pulse time modulator channel, and connects in its stead first a ground or zero voltage and then a stable reference potential of 3.5 volts. Two such calibrating units are built into each transmitter.

A large number of slowly varying quantities such as temperature and pressure may be measured through a single telemetering channel by mechanical commutation. When used, such mechanical commutators are provided as part of the instrumentation of the experiment concerned. For one V-2 rocket, temperature and pressure measurements utilized 16 commutated subchannels compressed into two telemetering channels.

Data taken by telemetering is correlated with radar tracking plots, optical data, and photographic records of the missile's trajectory by means of a master timing signal, so that telemetered information may be plotted as a function of the altitude of the rocket for the entire flight.

The timing signals originate at a special installation provided by a group from the Army's Aberdeen Proving Ground. A timing pulse is provided every half second above a 100-cycle background, beginning at the time of the rocket takeoff, with every twentieth pulse after takeoff omitted.

At the telemetering ground station, the time signals are fed to one of the Hathaway oscillograph recording channels to make a permanent time reference along with the telemetered data. The time signal also triggers time marking de-

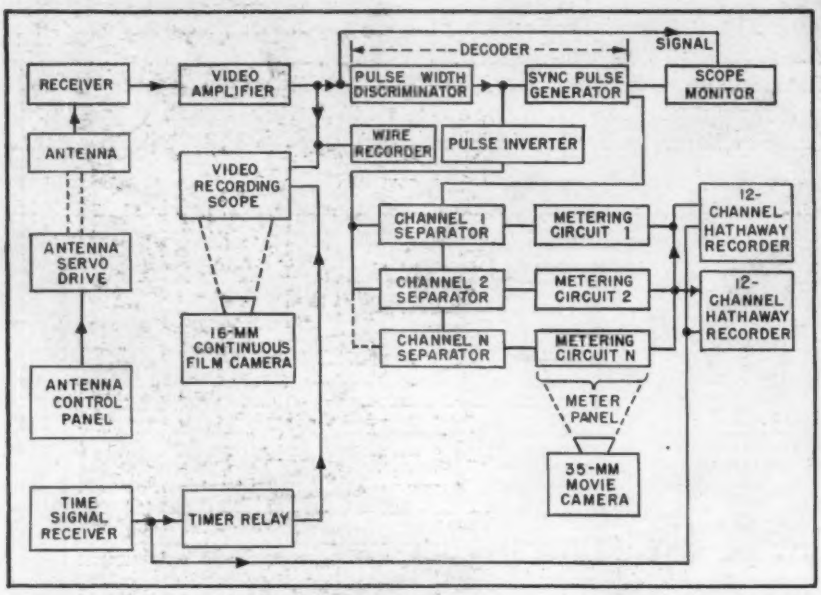


FIG. 2—Block diagram of equipment located in trailer serving as ground station for V-2 telemetering system

vices used with the movie camera, wire recorder, and continuous film camera.

The ground station antenna, located at the center of the trailer roof, can be directed either by an observer on the roof or by an operator inside the trailer. For the most part all operations work automatically during a telemetering run except for directing the antenna which is done both optically and by listening to the signal and maximizing the output. More than one ground station is used to lessen the chance of a break in the telemetering service. In all of the firings to date, there have been two mobile stations in operation.

Circuit of Airborne Telemetering Unit

The pulse time modulator in the airborne unit is designed to generate a time interval over the range of from 50 microseconds for zero voltage input to 200 microseconds for + 5 volts input signal. These times are measured from the leading edges of the two pulses defining a time interval.

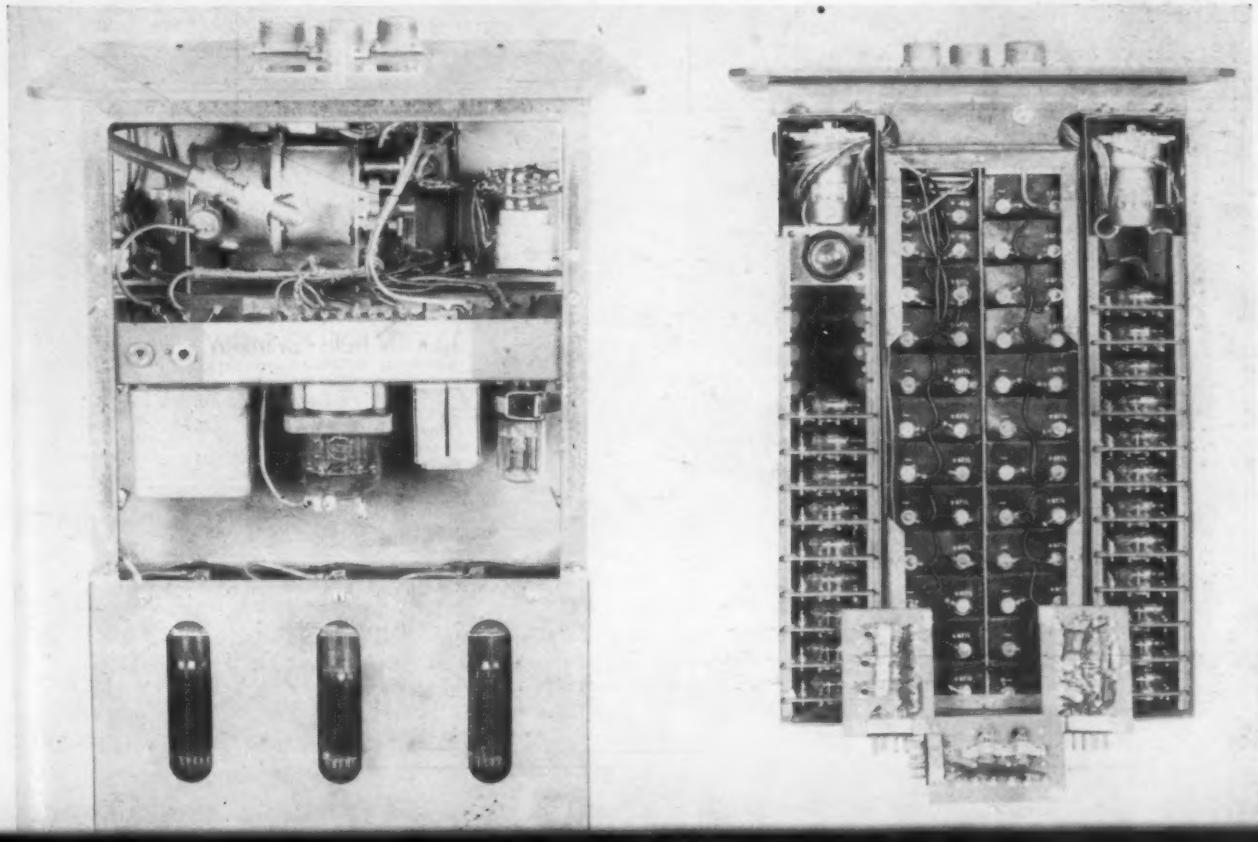
To maintain satisfactory differentiation between groups, it is necessary that there be a spacing of at least 600 microseconds between the last pulse of one group and the first pulse of the next. Furthermore, the full 200-microsecond period, corresponding to a + 5-volt input, might conceivably be required for all channels in one sampling cycle. Thus, the time required for the formation of a single group of telemetering pulses may be as long as 5,200 microseconds for a 23-channel system. In such a case, the maximum allowable repetition rate is 192 cycles a second. With such an arrangement, data voltages fed into the telemetering channels are sampled 192 times a second.

The circuit diagram of the airborne unit appears in Fig. 3, and corresponding wave forms at ten different points in the circuit are shown in Fig. 4. All electronic circuit functions are initiated by a master keyer, which is simply a freely running multivibrator. The period of the multivibrator of the master keyer is the pulse group repetition period, and is set by adjusting R_1. The output from the master keyer (point A) consists of square waves which are coupled through short time constant circuits to channel 1 and the channel collector.

The positive surge from the keyer does not affect either channel 1 or the channel collector. The surge does not affect V_4 because the grid is already at full conduction potential. It does not pass to the channel collector because it is blocked by diode crystal X_1. At time t_1 the negative surge from the keyer, acting on the blocked multivibrator of channel 1, triggers it from its normal state to a temporary state (from a state in which V_4 is conducting to a state in which V_3 is conducting). As a result of the negative surge impressed on the grid of V_4 the potential of the common cathodes drops until V_3 begins to conduct. Conduction of V_3 produces a negative surge at its anode, which is coupled to the grid of V_4 to drive that grid still further negative. Channel 1 now remains in its temporary state until the charge impressed upon this grid leaks off through resistors R_2 and R_3.

During the temporary state of channel 1, the grid potential of V_4 rises at an exponential rate determined by C_1, R_2, and R_3. At time t_2, after the grid of V_4 has returned

Two views of airborne unit out of housing. At left is the oscillator cavity (upper section) with 2C43 disk-seal tube operating at 1,000 mc, and 3E29 modulator tube mounted upside down below it. At right are two groups of pulse time modulator circuits and the high-voltage supply battery. Three of the plug-in ptm units are removed from their sockets to illustrate the use of subminiature tubes. Motors in upper corners drive the calibrator units that apply known voltages at regular intervals in place of instrumentation voltages



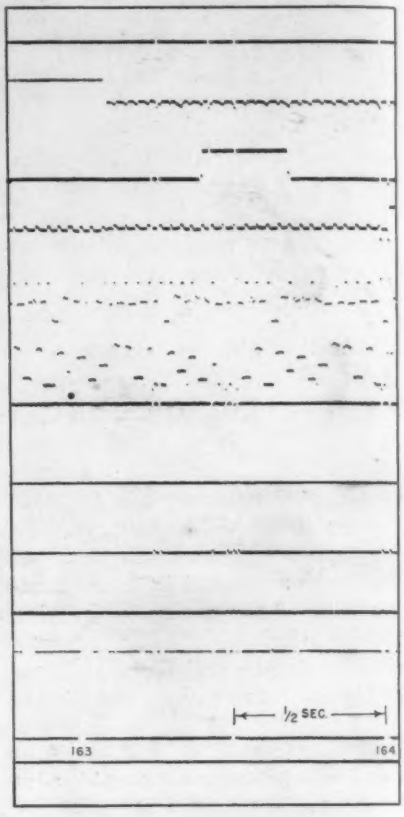
Complete telemetering airborne unit in 14 x 14 x 20-inch pressure-sealed case weighs only 150 lb. including 1,000-mc dipole

sufficiently positive, conduction in V_4 again begins; the cathode potential rises, a positive surge is generated at the anode of V_3 which is coupled to the grid of V_4, the circuit returns to its steady-state condition, and a negative surge is generated at point D. This surge, coupled through short time constant circuits to channel 2, initiates in channel 2 an action similar to that which took place in channel 1. Such action continues from one channel to the next, the return of a channel to its stable state triggering the succeeding channel to its temporary state, and simultaneously delivering a pulse to the channel collector circuit. When the last channel is reached the action stops and does not repeat until a pulse from the master keyer once more triggers channel 1.

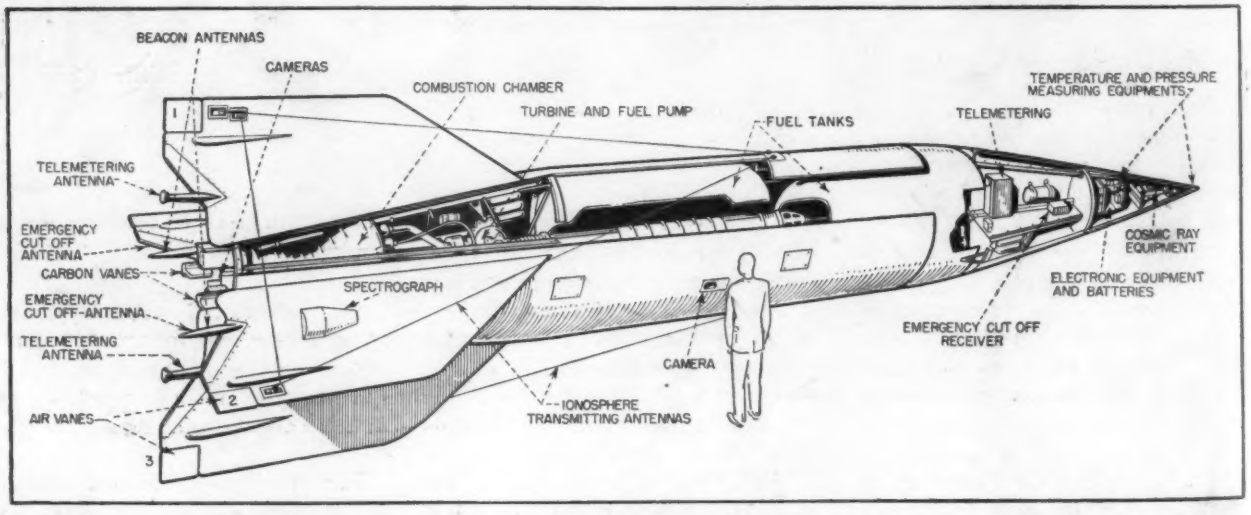
The length of time during which each channel remains in its temporary state is determined by the voltage input to that channel. Each channel is calibrated so that with 0 volts applied to the input, the temporary state is of 50 microseconds duration, and with 5 volts applied to the channel the temporary state is of 200 microseconds duration. The calibration procedure, as illustrated in connection with channel 1, consists of first setting the input voltage to zero and adjusting R_2 until the temporary-state duration is 50 microseconds. Then with a positive voltage of 5 volts applied to the input, R_4 is adjusted until the temporary-state duration is 200 microseconds. Fixed resistances matching the values of R_2 and R_4 are then mounted in place of the temporary variable resistances. The applied voltage is effective both upon the triggering and the return of each channel.

A positive voltage on the grid of V_3 produces a much heavier conduction in that tube when the channel is triggered. Hence, a larger negative signal is impressed on the grid of V_4 and therefore takes a longer time to leak off through resistors R_2 and R_3. Furthermore, the level to which the voltage must leak before conduction in V_4 begins is raised. As a consequence the voltage which is effective in determining the temporary-state duration is the input voltage which is applied during the temporary state. With this system of pulse-time modulation the duration of the temporary state of each channel can be made a linear function of the input voltage.

Upon the return of each channel to its normal state a negative pulse is transmitted through a small crystal diode to the common line G



Section of typical telemetering record. Numbers on time reference trace (second from bottom) indicate elapsed time in seconds since takeoff. Time reference pulses are a half second apart



Sketch of V-2 rocket equipped for study of ionosphere, showing location of telemetering unit in nose and telemetering antennas behind tail fins. In the first successful flight made for this purpose, all instruments recorded continuously until the huge missile landed 13 miles away after reaching an altitude of 63.5 miles

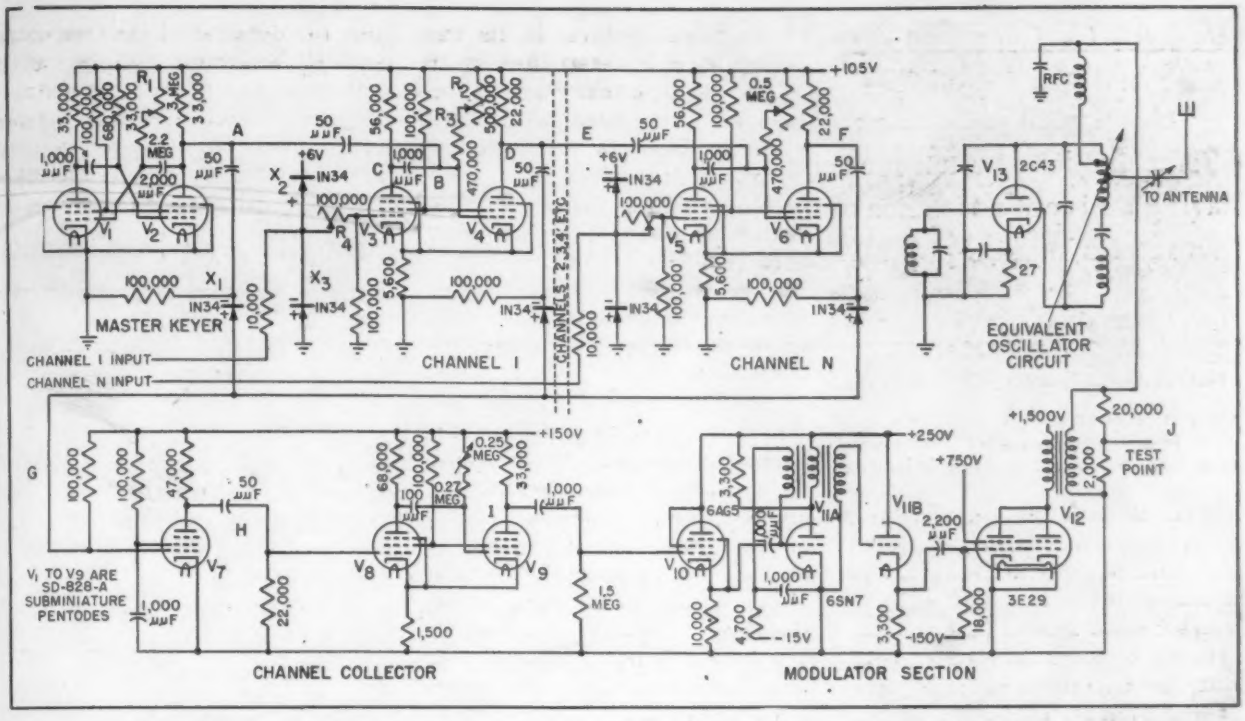


FIG. 3—Circuit of airborne telemetering unit. First and last channels are shown, others being identical

of the channel collector. The purpose of the crystal diodes is to prevent interference between channels and to allow a pulse of sufficient amplitude to reach the amplifier of the channel collector. Furthermore, only the negative pulse on the return of each channel to its normal state is transmitted through the diode to common line *G*. Thus, for 23 channels, 24 pulses in each group are transmitted to the grid of amplifier tube V_7, where they are amplified and inverted in phase to trigger the blocked multivibrator of the channel collector.

Operation of Channel Collector

The channel collector is similar in action to the channels themselves, except that its temporary state is made very short. The pulse generated by the return of each channel triggers the channel collector to produce an output pulse at *I* which is of constant duration and amplitude, regardless of the variation in the signal received from each channel. The periods between collector trigger pulses therefore occur simultaneously with the periods at which the respective channel multivibrators are in their temporary states. The information has thus been converted to a pulse spacing.

Positive pulses from point *I* of the channel collector first pass through cathode follower V_{10} and trigger the blocking oscillator V_{11A}, which in turn generates sharp pulses of one microsecond duration. Since the blocking oscillator is of a type commonly used in television synchronization circuits, its operation will not be described here. The one-microsecond pulse from the blocking oscillator is fed through cathode follower V_{11B} and hence at low impedance to the grid of the 3E29 modulator tube, both halves of which are connected in parallel. The grids of the modulator tube are driven to zero bias thereby causing the tube to conduct. A pulse transformer steps up the output pulse from the modulator tube and applies it to the r-f oscillator.

The antenna feeder line is capacitively coupled to the oscillator cavity. A peak pulse power output of approximately 750 watts is obtained at 1,000 mc, with a pulse width of approximately 0.8 microsecond at the half-power level.

Crystal diodes X_2 and X_3 are connected to the input of each channel to limit the input voltage to the range from 0 to + 6 volts. Too high an input voltage will cause a channel to oscillate, sending out a

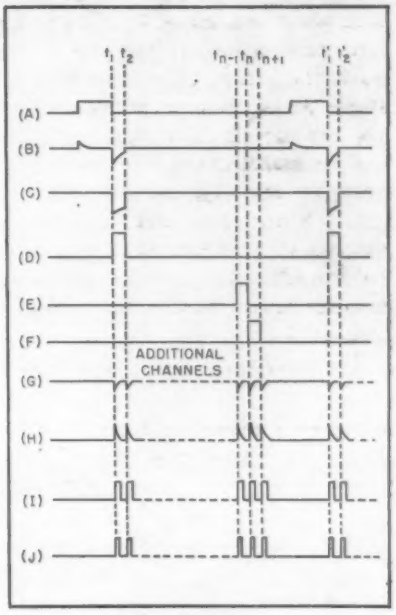


FIG. 4—Waveforms at various points in airborne telemetering circuit of Fig. 3

series of equally spaced pulses, while a negative voltage will completely stop the action of the multivibrator and prevent triggering of all subsequent channels in the system.

Part II will cover circuits used at the ground station for decoding pulses and metering circuits of various channels.

Electrometer Tube

C. D. GOULD

Senior Electronic Engineer
Victoreen Instrument Co.
Cleveland, Ohio

must it be properly located with respect to the rest of the structure, but the tension of the mounting springs must be maintained within fairly close limits. Otherwise, when the wire is heated to high temperature during the activation process, the filament will either stretch or sag by an amount sufficient to render it useless.

A typical diode-emission curve is shown in Fig. 1A. The point of interest is the knee in the curve at 9 ma. To the right of this point the tube is operating fully space-charge limited. By rejecting tubes which show this knee to the left of the 9.5-ma point, satisfactory operation at 10 ma and beyond is assured, and the plate current becomes much more independent of filament current changes than would be possible if operation on the vertical portion of the curve were attempted.

Emission capabilities of the filament are very high, being limited mainly by the burn-out point of the wire. Short-time filament overloads of 100 percent and higher have little effect on performance. By applying sufficient plate voltage to one of these tubes, diode connected, to draw 20 or 30-ma plate current, it is possible to have plate current continue undiminished even after the filament voltage is disconnected, due to the heating of the filament wire by the plate current flowing through it. Although such operation requires space currents that are too high for long life operation, the phenomenon has been used in r-f rectifiers.

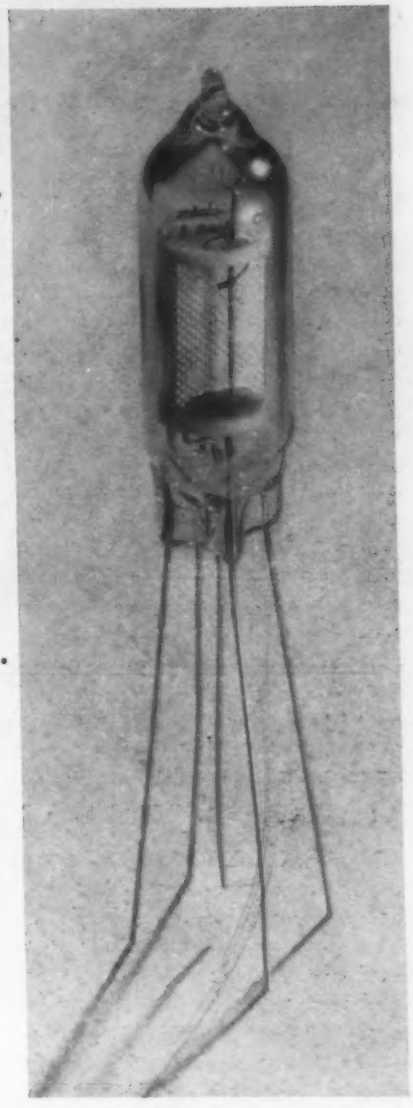
In actual operation the total cathode current is never more than about 250 microamperes, nearly all of which, in the electrometer connection, is drawn by the first (space-charge) grid. For the absolute ultimate in electrometer operation this grid is a necessity; operated at a positive potential of about three volts, it repels back to the filament the positive ions released during the emission process and prevents their reaching the negatively biased control grid.

The presence of this space-charge grid makes possible a number of different connections of the tube elements. The characteristic curves for these various connections are shown in Fig. 2A to 2D; the two used for electrometer work are shown in Fig. 2A and 2B. Figure 2A is the classical electrometer connection, and Fig. 2B is the inverted triode connection, which is extremely useful in certain types of work with higher voltages than can be handled with the straight electrometer. Figure 2C is the high-mu connection and Fig. 2D the low-mu connection.

High Input Resistance

The two great difficulties in using a vacuum tube as an electrometer, over and above positive ion emission from the filament, are gas current and leakage resistance. Gas current, caused by the migration of positive ions to the negatively charged control grid, can be controlled in three ways; for the ultimate in performance all must be employed. The first is the achievement of the highest vacuum in the tube that can be obtained. The second is operation with sufficiently low potentials on the tube elements to prevent ionization of the few gas molecules that inevitably remain even when all precautions have been taken in pumping. Hand in hand with this latter precaution goes the necessity of excluding any light whatsoever from the tube when it is in operation. Photoelectric emission of electrons from the control grid results in positive grid current indistinguishable from gas current, even with quite feeble illumination.

Leakage resistance, especially when the tube is operated under conditions of relatively high humidity, is a problem of extreme importance. In earlier models of the subminiature electrometer tube the problem was solved by cementing an amber bead around the



Electrometer tube shown twice actual size

Subminiature

Characteristics of a tetrode requiring only 13 milliwatts of filament heating power and having an input resistance of millions of megohms are presented. Applications to meters for measuring ion-producing radiations illustrate ways of simplifying power supply

DURING THE LAST SEVERAL YEARS, the need for a subminiature low-current vacuum tube capable of electrometer service became increasingly apparent. Ordinary tubes were unsuitable for a number of reasons. Tubes previously designed specifically for electrometer service were too bulky and in addition required prohibitively large filament currents for portable equipment. Smaller and more conventional types, such as the type 30, were capable of serving as electrometers if specially selected and processed, but even their size and filament requirements were undesirably large.

Electrometer Tube Requirements

Considerable experimentation was carried on to determine the feasibility of using hearing-aid tubes, but results were on the whole quite disappointing. Very few of them were adequately pumped, with the result that gas current was prohibitively high for the exacting requirements of electrometers. Furthermore, their characteristic in the low-current, low-voltage region, mandatory to electrometer operation, showed such wide variations that it was almost impossible to design a circuit in which any reasonable percentage of a given number of tubes would operate; and, finally, the drift encountered in these tubes was of a magnitude that would have prevented their use even in the absence of other factors. Such drift has an almost inappreciable effect on the operation of an a-c amplifier, such as a hearing-aid or miniature radio, but in a d-c amplifier it is hardly an exaggeration to say that anything else can be tolerated providing drift is small.

Having made an exhaustive survey of existing tube types, it was finally decided to embark on the development of an entirely new tube specifically for portable electrometer service. Two requirements were to be met: (1) the tube was to be capable of electrometer operation with total control-grid current of less than 10^{-14} amperes, and (2) the filament was to require no more than 10 ma at 1.3 volts, the arbitrarily set end-point of a 1.5 volt dry cell. The advantages of a filament capable of such operation were so numerous (one-month operation from an ordinary flashlight cell, to name but one) and it was felt that the time and effort required to develop it would be justified.

Several requirements for such a filament followed immediately from the 10-ma specification. (1) It must have a high specific resistance and the minimum possible cross-section to achieve the 130 ohms resistance necessary within the length allowable. (2) Oxide coating of some sort was a necessity because adequate emission could not possibly be secured otherwise with the filament power available (normally 13 mw). (3) The composition of the wire must be such as to yield adequate emission in combination with the oxide coating.

Characteristics of Tube

Experiments finally produced a filament with a nickel-chrominum base wire and an oxide coating of equal parts of barium and strontium carbonate, all commercial filament mixes having proved unsatisfactory for one reason or another. The wire base is the smallest that can be commercially drawn, having a diameter of approximately 0.0004 in. An idea of the minute size of the wire can be gained by dropping a length of it; even after coating, it floats downward like a spiderweb.

Mounting such a filament in the tube requires highly skilled operators and is the most difficult step in the assembly process. Not only

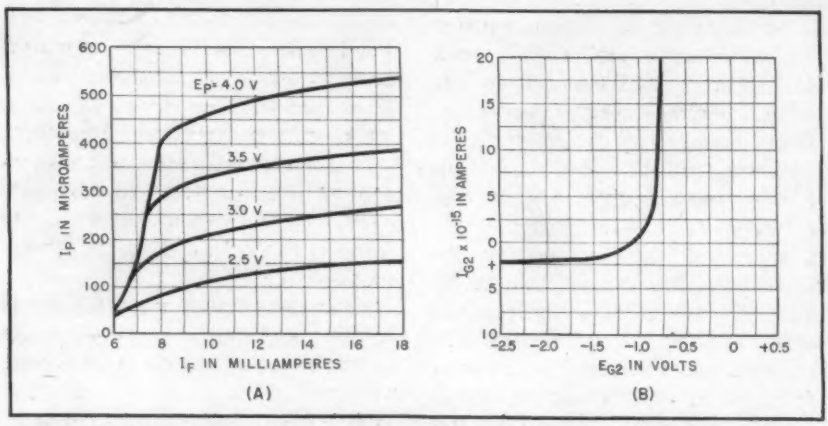


FIG.1—(A) Diode characteristics with both grids connected to plate indicate cathode emission characteristic. (B) With 10 milliamperes filament heating current, 250 microamperes first (space charge) grid current, and 10 microamperes plate current, this second (control) grid input characteristic is obtained

Accumulated effect of x-ray radiation is indicated directly in milliroentgens by this instrument; midscale indicates daily safe exposure. Figure 4 is the circuit

tion is quite simple, but considerable refinement of manufacturing technique was required to produce the instrument successfully because of the tremendously high resistance which must be maintained.

The shell on top of the instrument is a sealed ionization chamber containing a nonionizable capacitor and an electrometer tube operated as an inverted triode. The capacitor is charged by a device which will be described later, and supplies the collecting voltage for the ionization chamber. In the absence of radiation no ions are produced, and the charge on the capacitor remains unchanged. When radiation strikes the chamber, however, the capacitor will lose its charge by an amount directly proportional to the total quantity of radiation received. Thus to measure the total amount of incident radiation it is only necessary to measure the change in voltage across the chamber and capacitor; this function is performed by the electrometer tube.

Estimate of Leakage Resistance

It is obvious that for such an instrument to perform successfully the leakage resistance across the capacitor, chamber, and electrometer tube must be almost infinite, and gas-current in the electrometer almost zero. Some idea of the magnitude of these requirements may be had by considering the performance of these instruments as produced.

The total capacitance of the chamber, capacitor, and electrometer grid is about 100 micromicrofarads. This capacitance is charged to −24 volts initially and when discharged (a condition that represents twice the maximum daily tolerance dose) this potential drops to −6 volts. In the absence of radiation the meter will move two percent of full scale per day. This drift of course includes the effect of the background of cosmic radiation which is present at all times everywhere, but by assuming this equal to zero we can arrive very simply at an upper figure for leakage and gas current.

Daily drift corresponds to two percent of 24 volts minus 6 volts, or a voltage change of 0.36 volt per day across 100 micromicrofarads. Because $Q = CE$ (where Q is charge on capacitance C at potential E), this voltage change represents a loss of charge of 36 micromicrocoulombs per day, which is equivalent to a current of 4.15×10^{-16} ampere. It is difficult to allocate this leakage between gas current and leakage current, but the fact that the drift rate is nearly constant from one end of the scale to the other indicates that most of it must be gas current. If it were all due to leakage current the amount of leakage resistance (assuming the chamber fully charged) would be given by $24/(4.15 \times 10^{-16})$, or 6×10^{16} ohms, approximately. It is safe to assume that it is at least ten times this amount, or nearly one million million megohms.

The charging circuit for the chamber is of some interest. Apart from the 24 volts necessary to charge the chamber, the entire instrument can be operated from a 6-volt supply. This supply is made 7.5 volts to allow for aging of batteries, and is furnished by five flashlight cells. To step this voltage up to 24 volts, current is momentarily passed through a small choke loaded with a resistor. The voltage pulse developed when the current starts is ignored. When the current through the choke is suddenly interrupted, the voltage which will appear across the choke can be made any value desired, up to a few hundred volts, by properly proportioning the shunt resistor. To a first approximation (neglecting the effect of the resistance of the choke) the ratio between supply voltage and developed voltage equals the ratio of the series resistor to the shunt resistor. Because the capacitance of the grid circuit chamber requires only a minute charging current it will be charged nearly to the full voltage developed across the choke.

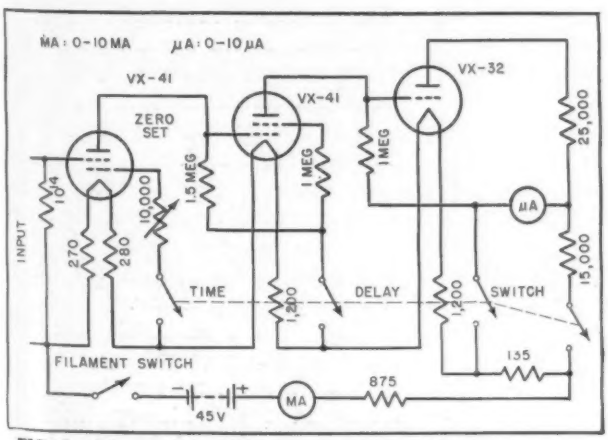


FIG. 3—Circuit of portable instrument for indicating intensity of low-level radiation

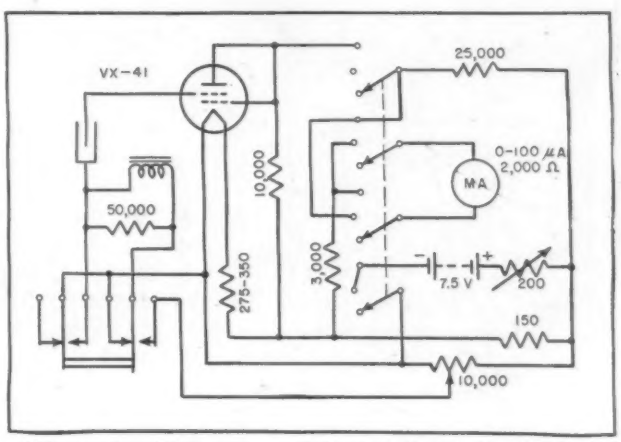


FIG. 4—Cumulative x-ray radiation is indicated by this direct reading integrating meter

control-grid lead to isolate it from the remaining leads. With the advent of silicone water repellant substances, however, a much more satisfactory solution to the problem was obtained by coating the tube base around the control-grid lead with a silicone preparation and baking this on at high temperature. The resulting grid-circuit input resistance is of the order of 10^{16} to 10^{18} ohms, and strongly resists anything but direct contamination by dirt or fingerprints. Even when the surface has been contaminated, it can be restored very simply by washing with alcohol and distilled water, using a soft brush, and baking in an oven for a short period at about 100 C.

The VX-41, as finally developed, easily met requirements for low gas current originally imposed. A graph showing control-grid current for the electrometer connection is given in Fig. 1B. This curve is for an average tube; selected specimens will have grid current of one-tenth to even one-hundredth the amount shown in the curve. Furthermore, great improvement can be had in this respect by operating the tube at an even lower plate voltage than the six volts used here; operation with only four volts on the plate gives a very significant reduction in grid current.

Grid current in the inverted triode connection is as small as in the electrometer connection, because here again the element next to the cathode is operated at a positive potential, and serves to return positive ions to the filament.

Application to Radiation Meters

Because our primary concern is the measurement of radiation and radioactivity, the uses to which these tubes were first put were in this field. The first instrument designed using the VX-41 was a sensitive portable radiation meter, a simplified circuit of which is shown in Fig. 3. The ionization chamber in the input circuit of the first tube consists of a cylindrical metal tube with very thin walls, and with a center electrode mounted coaxially and insulated from the shell. A potential of 45 volts between these two is sufficient to collect all the ions produced in the chamber by the low-intensity radiation that this device was designed to measure. The third tube in the circuit, the VX-32, was designed specifically as a current amplifier to operate a meter. It has an amplification factor of only 1.5 and the relatively high mutual conductance of 150 μmhos, and as it is pumped and insulated in exactly the same manner as the VX-41 it can itself be used as an electrometer, with somewhat greater sensitivity than the VX-41, where more grid-current can be tolerated. Grid-current in the VX-32 is about ten times that in the VX-41.

It will be noted that one 45-volt B-battery supplies both plate and filament current for the entire amplifier, at a total drain of somewhat less than 11 ma. The use of a single battery simplified the replacement problem tremendously. In the actual instrument, the on-off switch carries a battery test position whereby it is possible to set the filament current at exactly 10 ma; when this can no longer be done the battery is replaced.

The radiation meter described above measures the rate at which radiation strikes the ionization chamber. The higher the radiation, the greater the number of ions produced, the greater the current through the high input resistor, and the greater the voltage across it. However, because the effect of high-voltage radiation such as x-rays on the human body is cumulative, a device which will indicate the total amount of radiation received in a given location is of prime importance. X-ray technicians and cyclotron operators, for example, are exposed to varying amounts of radiation in the course of a day. By the use of an instrument which indicates total quantity of radiation it is possible to monitor the location in which the operators work, and make sure the total amount of radiation received in one day does not exceed the tolerance dose. Such a device is the protexi-meter, shown in a photograph and in Fig. 4. The principle of opera-

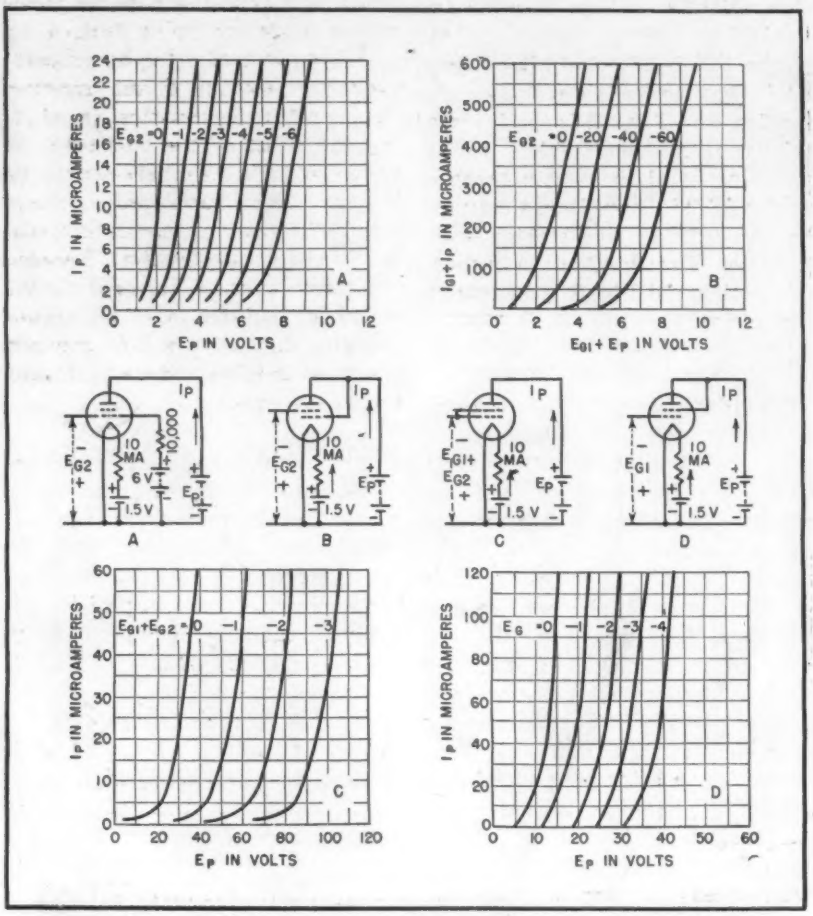


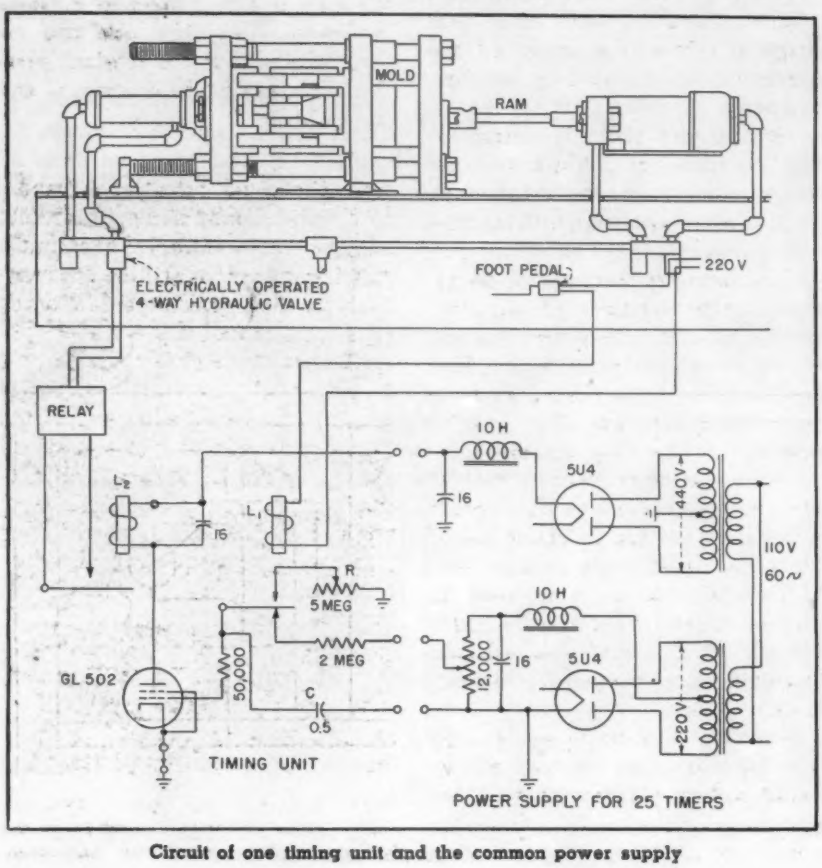
FIG. 2—Transfer characteristics obtained with tube connections shown

Power supply and two of the units. A spare supply is available for immediate plug-in should breakdown occur

TIMER for Diecasting Machine

Accuracy and efficiency of diecasting with aluminum and zinc is obtained by an electronic timer that determines the interval between the shot or molding action and the ejection of the casting from the mold

By GERALD DeLONG
Cannon Electric Equipment Co.
Los Angeles, California

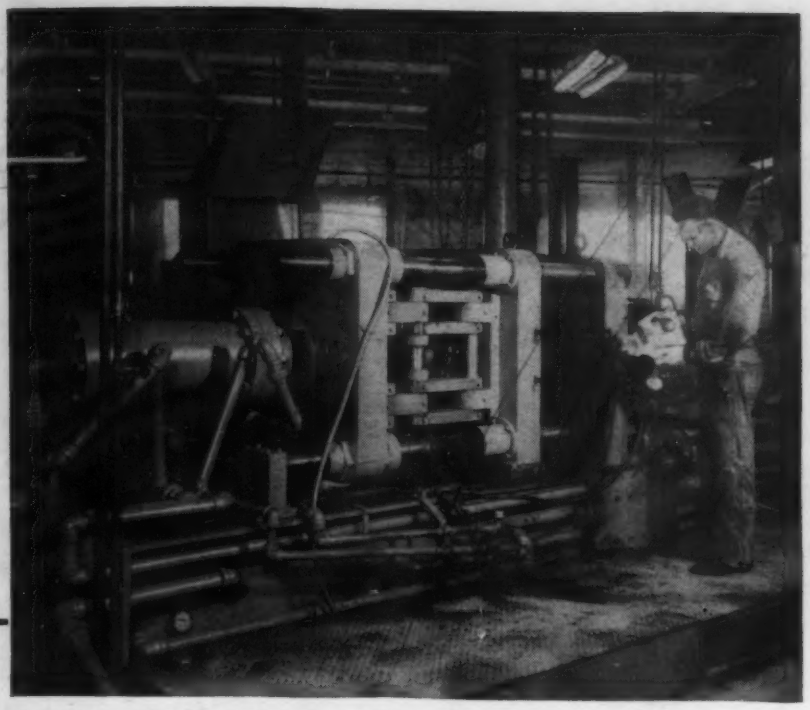


Circuit of one timing unit and the common power supply

CANNON ELECTRIC diecasts for other firms such parts as roller-skate wheels, crank-cases, pistons, cylinder heads and parts for motor scooters. The precision requirements of these diecastings involve exacting tolerances, and the normal human variations of an operator's timing of the diecasting process may result in a warped or otherwise imperfect casting.

Before the installation of the electronic timing unit to be described the time lapse for cooling or setting up of the metal in the mold was controlled arbitrarily by each operator. If the operator were on piece work a tendency frequently developed whereby the operator opened his machine as quickly as possible after each shot. On the other hand, if the operator were fatigued or his sense of timing slow he might allow excessive time to elapse before he opened the mold and ejected the casting.

Tests proved that this interval was a critical constant for a given type of mold. Any significant decrease in the arbitrary interval value (reduction of 0.1 second or more) resulted in a plastic deforma-



Diecasting machine for aluminum and zinc. Automatic control of the cooling period of the metal in the mold is obtained by a decay circuit

tion. Greater tendency for cold-flow warping during machining was also evident.

In developing the timing unit, it was found that in most thyratrons the grid does not have complete control over the plate current; it can initiate the flow of current yet has no power to stop the flow once it has begun. In the type selected, the control grid controls the flow of current between cathode and plate and can be biased to cutoff without removing the plate voltage.

Circuit Operation

A negative potential up to 200 volts may be applied to the control grid of the tube. This can be drained off to ground—in this instance through a variable resistor to ground—until the voltage ranges from 3¾ to 0.9 volts at which point, depending upon the performance of the individual tube, the tube fires. To restore the tube to normal, high negative bias voltage is applied to the grid.

In the cycle of operation, the operator closes the diecast mold, and pours molten metal from a ladle into the machine. He then steps on the foot pedal which rams the molten metal into the mold at high pressure and at the same time closes the initiating relay on the electronic timer, starting the timing cycle.

The contacts of the initiating relay L_1 normally apply the bias to the control grid of the tube and the tube is quiescent. Operation of the foot pedal actuates the 220-volt relay coil L_1, causing the bias to be removed from the tube, allowing capacitor C to discharge slowly through variable resistor R. This resistor allows the timing cycle to be changed from 0 to 18 seconds as required by the shop foreman.

When the negative potential at the grid decreases to the proper value, the tube fires. The firing of the tube causes plate current flow to operate relay L_2. This relay in turn operates a second and heavier solenoid that actuates a solenoid hydraulic valve to open the diecasting machine.

When the machine begins to open, the operator takes his foot off the pedal, pulling the ram back. This also removes the current from the coil of the initiating relay, allowing the contact arm to snap back and apply the bias voltage to the control grid of the tube, causing the tube to cease firing and complete the cycle.

Individual Timers

Since the diecasting machines turn out a variety of products, each machine requires its own timing control unit, and 25 timing units are installed in the plant. These are assembled in one central rack and fed from a common power supply. The removal of one unit does not interfere with the operation of the other units.

The central control rack is furnished with a door that is kept locked and the key is in the possession of the foreman of the section. When a new mold is set up in one of the machines, the foreman determines the mold curing time, and sets the variable resistor R in the corresponding timing unit for the number of seconds that it is desired the die shall remain closed.

The operator of the diecasting machine closes the die manually, pours the charge of metal and kicks the foot switch. From that point, the electronic gear takes over, times the cycles, opens the mold and returns the ram to its original position. The cast piece is removed and the cycle starts over again.

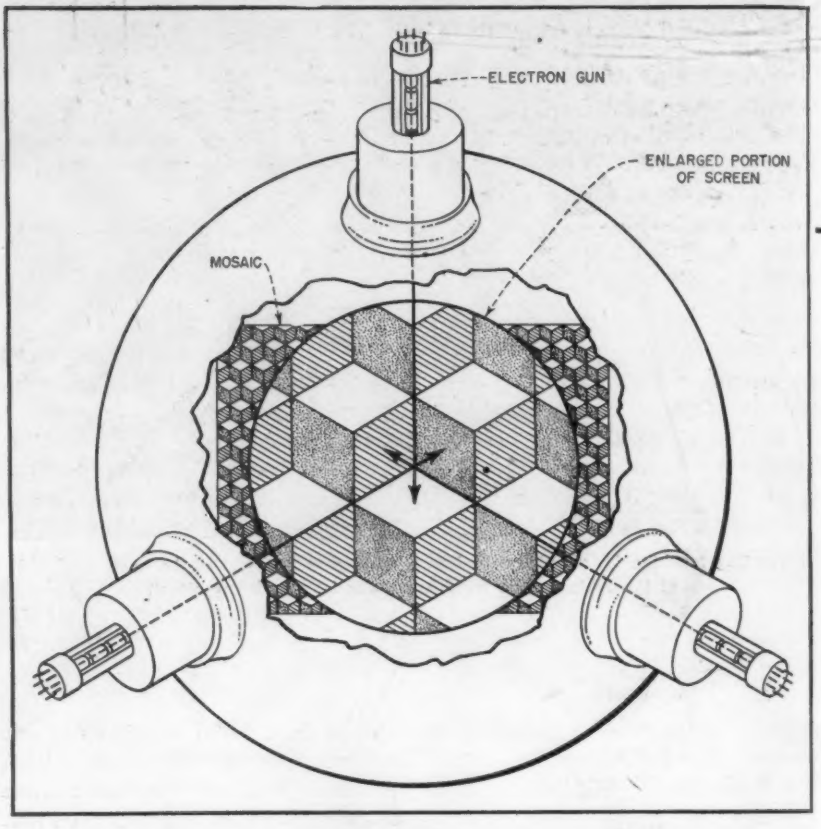
The central control rack contains 25 timing units. These are only accessible to the foreman of the section for adjustment

Experimental C-R Tubes

RESEARCH INTO PHOSPHORS and methods of reproducing television images indicates that television receivers can be made to give bright, detailed images in either monochrome or polychrome.

Many experiments now in progress would not ordinarily be discussed until they were nearer commercial application. However, in view of present engineering and economic discussions on the possibility of translating color television into a public broadcasting service, it seems advisable to describe briefly several cathode-ray tubes that will be available in a few years. Thus engineers faced with the necessity of making immediate executive decisions about future developments will have available the facts, not only of presently available means, but also of future potentialities on which to base their decisions.

The following description of tubes and equipment is based on a recent tour of the Allen B. DuMont Laboratories.



Cutaway drawing of back of Trichromoscope shows how three guns paint three-colored picture on embossed mosaic on face of tube (seen here from behind). In experimental model, mosaic (not shown to scale) covers only portion of tube's face. Section of mosaic in center is shown much enlarged

Screen Brightness

To increase the screen brightness from cathode-ray tubes, the beam current and potential can be increased. Beam current is limited by the size of the focused spot. In large tubes, high beam currents can be used because the absolute size of the spot that will just cover a television picture element is large. Thus a bright picture can be produced from a large directly viewed tube.

When beam potential is increased, so also are difficulties and danger from the high voltages, and there may be production of x-rays by high-velocity electrons. Moreover, effectiveness of the high beam potential in projecting electrons at high velocities onto the phosphor of the screen is partially counteracted by the space charge that accumulates at the screen. To realize the full possibilities of a high beam potential, it is therefore desirable to remove as fast as possible the electrons that reach the screen.

This removal can be done by providing a metallic backing to the phosphor screen. The metallic backing has to be thin enough not to slow down the beam electrons, but thick enough to provide a conductive surface over which electrons can move. Also, if it is optically flat, the backing can be used to reflect forward the light given off into the tube, by the phosphor, which would otherwise be wasted. Both actions of the metallic backing increase the efficiency of the tube. The backing is aluminum vaporized onto a flat intermediate surface produced by an organic coating deposited on the phosphor. The organic coating is then evaporated, leaving a mirror surface supported on the tips of the crystalline phosphor.

A 12-inch cathode-ray tube using a medium-persistance (P4) standard white phosphor that gave 20 foot-lamberts at 10,000 volts without the aluminum screen backing gives 300 foot-lamberts at 20,000 volts with an aluminum backing. Intense ambient lighting, 150 foot-candles of incident floodlighting, completely washed out the picture on the dim tube but did not destroy the visibility of the picture from the bright tube. Even 1,000 foot-candles, comparable to direct sunlight, did not completely wash out the brighter picture.

The life of such a bright picture tube is not materially reduced because the electrons penetrate more deeply into the phosphor (as a consequence of the prompt removal of electron charge by the metallic backing) than in the unbacked

for TELEVISION

Several new types of cathode-ray tubes for television receivers are in development; a tube having a screen brightness of 300 foot lamberts for monochrome receivers, a projection tube and a direct viewing tube both for polychrome receivers, and a tube having a very fast response phosphor for use in Photovision relaying

tube and thus cause less burning of the phosphor. The distribution of gun potentials in the tube is modified to take advantage of the greater obtainable contrast. In an unbacked screen, the negative charge would become greatest at places of greatest brightness, thus preventing further bombardment of that spot in an effort to make it brighter—a saturation effect. In the metallically backed screen, such saturation is greatly reduced so that much greater brightness contrast is available at the receiver. This type tube is going into production.

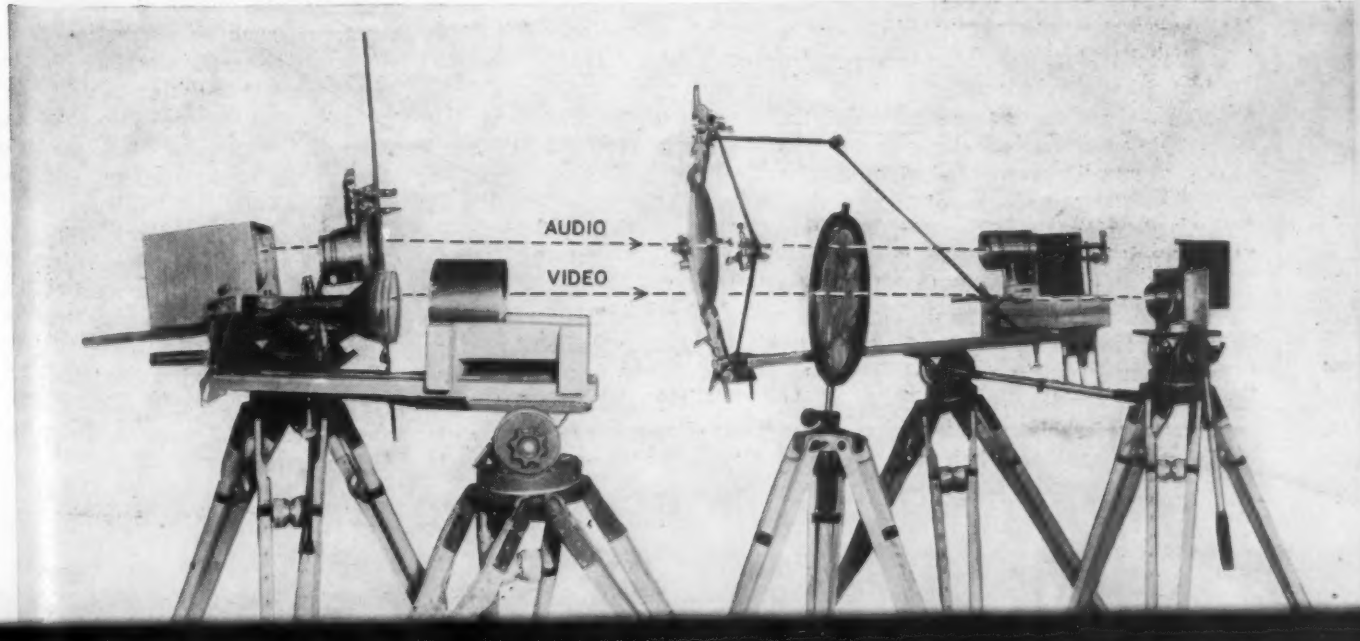
Flicker

For the received television picture to be observable without fatigue in a normally illuminated room, the picture must be reproduced at a brightness level well above the ambient light level. Therefore the trend in developing cathode-ray tubes for television receivers has been toward producing the brightest possible picture. So far, a picture so bright that flicker (which becomes more noticeable as the viewed picture becomes brighter) would become apparent with the standard repetition rate of 60 fields a second doubly interlaced to give 30 full frames a second has not been commercially producable. But with 300 foot-lamberts, some flicker is apparent under some conditions.

The duration of persistence of vision decreases relatively as the object brightness increases. Thus, for a fixed rate of picture interruption, there is a limit to the brightness that can be used in reproducing the picture before flicker becomes apparent. Also, the closer the viewer is to the picture (more correctly, the greater the angle subtended by the picture at the eye), the more noticeable is any flicker. But the greater the ambient illumination the less apparent is the flicker.

There are several types of flicker produced by television pictures. Monochrome pictures are reproduced 60 times a second. Thus there is a field repetition rate flicker in which the whole picture is seen to fluctuate in brightness, usually in an observable motion with the scanning pattern. In addition, because two different fields are being reproduced by the double interlace form of scanning, there is a fine detail or interlace flicker in which sharp edges and other small details comparable in size to a single pic-

Laboratory Photovision setup shows the elements of the system. Light serving as the transmission media for video and audio signals is generated (left) in two separate cathode-ray tubes and focused by lenses. Two spots on one tube could be used just as well. At receiver, (right) lenses collect transmitted light and focus it on electron multiplier photoubes. Large lenses are used experimentally to simplify alignment of optical system. Black boxes indicate simplicity and compactness of electronic circuits



ture element are seen to vibrate between adjacent lines, one line in each of the two interlaced fields, at the 30-cps rate of the full frame. This latter form of flicker, being the slower of the two, is the first to be noticed.

For conditions that make flicker most apparent, close viewing distance and low ambient illumination, interlace flicker is apparent in a picture reproduced on the experimental 12-inch tube at brightnesses above about 300 foot-lamberts. However, an ambient lighting of about 100 foot-candles and a viewing distance of about three feet (five times the picture height) counteract the interlace flicker at this picture brightness. In other words, for a normally lighted room and a viewing distance that would permit several people to watch the screen, no flicker is apparent. Of course the picture brightness could be reduced by the viewer to a level appropriate to the conditions under which it is viewed. As the ambient illumination increases, picture contrast decreases because, although the white becomes whiter and the black becomes less black, the ratio of the brightnesses of the white to the black decreases.

Tubes for Color Television

Polychrome pictures can be reproduced brightly as a result of development of colored phosphors. Phosphors that give saturated primary colors at high brightness, and thus eliminate the light losses of filters, have been developed. In addition, the elimination of the filters simplifies the optical system. Furthermore, the use of separate colored phosphors in a sequential color scanning system makes it possible for the individual phosphors to have a decay characteristic about as long as for a simultaneous system, thus increasing the available light from the sequentially reproduced picture and decreasing the degree of flicker. But increasing the decay time of the phosphors in an effort to increase the brightness would tend to accentuate the color breakup inherent in the sequential system.

By using a multigun cathode-ray tube and by dividing the screen into several preferably equal rectangular areas, each area being coated by a different phosphor, a single tube serves for the three tubes recently used in demonstrating simultaneous polychrome television. Of course the same tube could be used in a sequential system by electronically switching from gun to gun in accordance with the color sequence; however, the picture would not be as bright in this case as in simultaneous operation. In either case, lenses project the primary pictures onto a viewing screen. The individual color rasters can be positioned electronically to register them. No crosstalk is encountered between the several electrostatic deflection systems of the several electron guns.

In the laboratory model of such a tube, four guns and four screen areas were provided. In addition to the three primary colors, a white was added. In comparing the range of colors obtainable, it was obvious that the addition of a white channel added to the range of colored light values that could be reproduced, just as the use of a black plate in four-color printing adds a gradation not obtainable if only primary colors are used. The use of a dark (nonreflecting) screen would accomplish much the same result without the added transmitted bandwidth of a fourth channel.

For direct viewing, the Trichromoscope produces a three-colored picture. In it, three guns, each modulated by one of the three color channels, scans the screen from a different angle. The magnetic deflection yokes of all three guns are driven in series from a single deflection generator so that the three beams scan in perfect synchronism. The screen surface is a series of three-sided pyramids. The beam from one of the guns strikes but one side of each pyramid. Those sides of the pyramids that are oriented in the same direction, and are therefore scanned by the same gun, are coated with the same colored phosphor. Thus each picture element on the screen of the cathode-ray tube consists of three separate areas of colored phosphor. Using a metal backing for the screen to prevent secondary electrons from one phosphor from exciting adjacent phosphors of other colors, as well as to prevent loss of back light and to conduct away the charge from the screen, 600 foot-lamberts of directed brightness are expected from this tube. Such great brightness can be obtained because the pyramidal mottling gives roughly three times the surface area of phosphor to each picture element as contrasted with a plain-surfaced screen. Flicker would be noticeable using this brightness at present repetition rates if the tube were viewed from short distances.

Eventual economical manufacture of the Trichromoscope in commercial quantity is as much a factor in engineering its development as the design of the tube itself. The screen is shaped for test models by an ultrasonic engraving technique. A soft die with the pyramidal pattern milled on it is coated with a very fine grinding compound and placed on a plate of glass. The glass and die are then placed in an ultrasonic vibrator. So much energy is delivered to the interface between die and glass by the very high frequency of the vibrator despite its low amplitude that the grinding compound eats into the hard glass. The die must be enough softer than the work to act as an efficient carrier of the grinding compound. The cross-knurled pattern of pyramids is such that, except at the edges of the patterned area, it is the same on the die as on the work, so no complicated inversion need be made in machining the die.

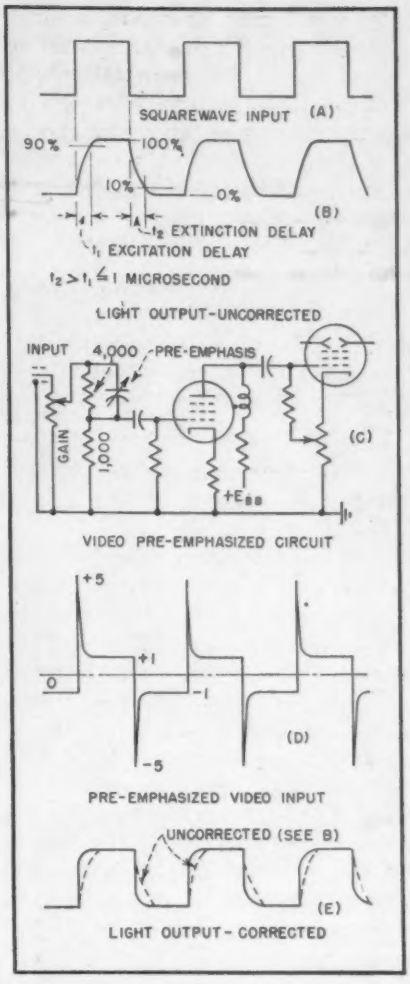
For quantity production the soft die will be used to cut a hard die, on which it would be difficult to machine the very fine pyramidal pattern. The hard die will then be used to press the glass face for the cathode-ray tube just as other intricate patterns, such as diffraction gratings, are pressed into glass. At the same time that the pyramidal pattern is being pressed into the back side of the glass, a multilens pattern can be pressed on the front side. With individual lenses over each pyramid, the light from the Trichromoscope would be directed forward, concentrating most of the light into the angle from which the tube would normally be viewed. (It is undesirable to view the television receiver screen from too oblique an angle because of the foreshortening of the figures.)

Phosphors are deposited on the faces of the cathode-ray tubes by settling from suspension. In the Trichromoscope, the tube is so oriented in the phosphor suspension that all the faces on the same sides of the pyramids are horizontal. The phosphor then settles on the upturned faces and not on the others. In this way the three different phosphors can be deposited on their appropriate sides of the pyramids.

Photovision Tubes

For relaying television signals over distances up to five miles (about the same distance between relay stations as between repeaters on television coaxial links), and where line of sight relay paths are obtainable, Photovision can be used. The technique is to modulate continuously the intensity of a beam of light just as one amplitude modulates a radio-frequency carrier with the video or audio signal, and to project the beam to a phototube at the receiving station. Basically the technique is simple. Practically it has been used for telegraph signalling by the Navy for years. Experience has shown that it is quite possible to transmit audio over light beams for distances of five miles despite severe weather including fog and snow storms. But to modulate the beam with a video signal at upwards of six megacycles per second has required some research!

The speed of response of phosphors had to be made quite fast for sequential television reproduction to be free of color overlapping. With the experience gained in developing such fast-response phosphors it seemed that a phosphor might be developed that would have fast enough response for use in Photovision. The rapidity of response of a phosphor can be increased by decreasing the crystal size and the screen thickness, and by increasing the excitation current per unit area. Fortunately high beam current density is compatible with the requirement for great brightness necessary for operation well above the system noise level. However, the high currents would burn the screen, so the phosphor is deposited on a rotating disc which is driven by an induction motor through the glass envelope of the tube.



If a squarewave (A) is used to intensity-modulate a phosphor, the light output (B) from the phosphor will show finite rise and decay times. A compensating network (C) can be introduced into the intensity-modulating amplifier; it adds a large differentiated spike to the squarewave (D), with the result that the light output (E) closely duplicates the waveshape of the original input signal

Using fast-response zinc oxide deposited very thinly in fine crystals, a sufficiently fast-response screen with adequate brightness was obtained.

The rate at which a phosphor reaches its full light output after inception of excitation is very fast; the rate at which it stops radiating light after excitation ceases is slower. However, the excitation and extinction rates are not so different that they need be considered separately for a first approximation. One might consider the phosphor as having a limited high-frequency response. High frequency compensation is therefore added to the electrical circuit to counteract the inadequacies of the phosphor.

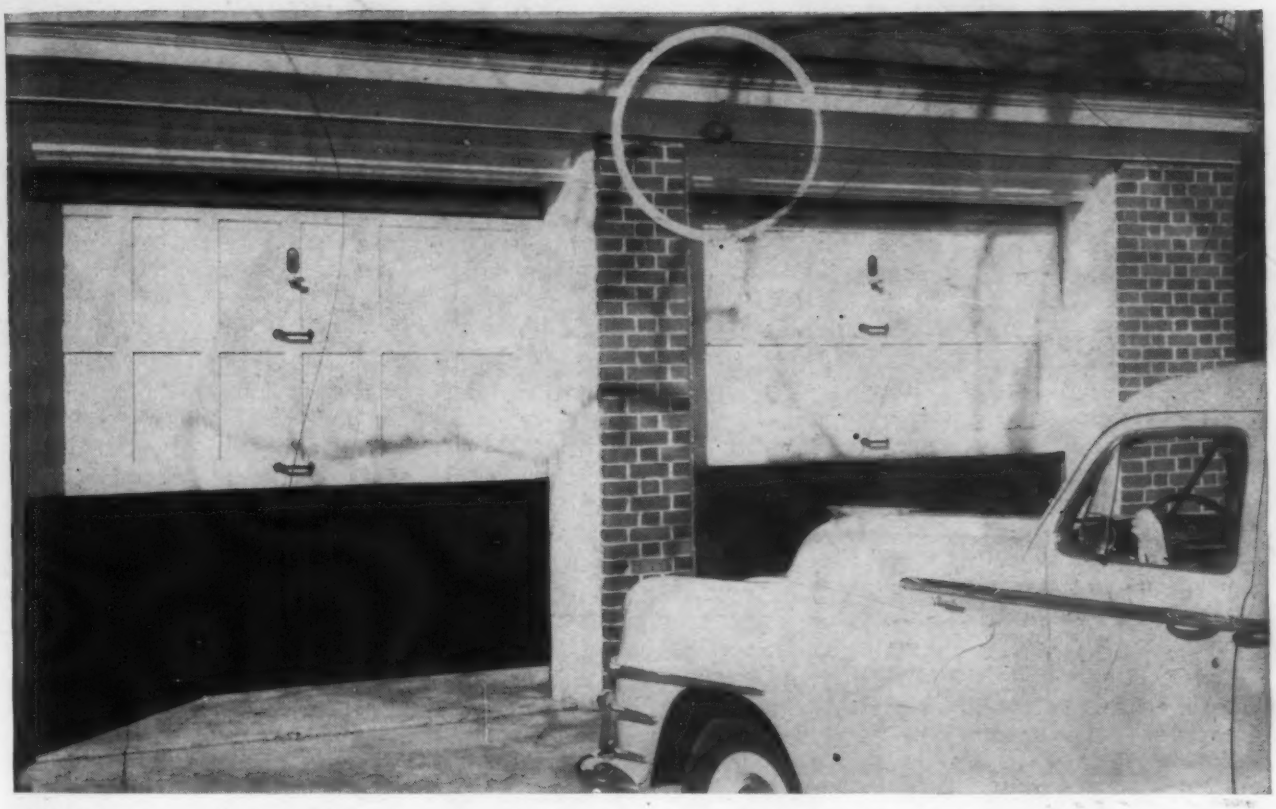
The Photovision system is comparable with coaxial or microwave relay systems. The cathode-ray tube light modulator replaces the complex carrier modulators of the other relay systems; negligible modulation power is required. A lens system at the transmitter focuses the beam to an electron multiplier type phototube at the receiver which replaces the superheterodyne preselector, converter, intermediate amplifier, and demodulator stages. Additional video amplification is used in all relay systems to bring the signal to the desired working level.

Either a duplicate system can be used to carry the voice channel, different phosphor colors (different carrier frequencies) can be used, or the voice can be carried on a subcarrier that translates it above the video channel. Either of the first two methods could be used to carry the extra color channels of simultaneous polychrome television. A messenger signal is used as in other transmission systems to provide a reference signal for the automatic gain control at the receiver that compensates for variable losses of the transmission path. Noise in the Photovision system is very low. The transmitter and receiver are sufficiently small and light not to require an elaborate tower.

One of the complications in the development of a workable public television service is the difficulty of providing network links between stations. The expense of producing television shows is so high that, unless an audience of a size only procurable through network facilities can be reached, the cost would be unjustified. As a relay technique for forming television networks, Photovision can also be used to advantage in relaying neighborhood pickups back to the studio, and in supplying exclusive television transmissions to motion picture theaters. With a distinct possibility that the microwave spectrum will become congested, Photovision offers a means of line-of-sight relaying no more limited in range than the ultrahigh frequencies and with such greater directivity that the number of links in simultaneous operation in an area is nearly limitless.—F.R.

Garage-Door Opener

Crystal microphone above door picks up 25,000-cycle wave produced by vacuum-type whistle on automobile. Five-tube amplifier with limiter and discriminator allows desired ultrasonic signal to actuate relay in motor circuit while rejecting extraneous sounds



Typical installation of microphone on two-car garage, between doors (in circle). Driver pushes button on dashboard after turning into driveway, and doors are open by the time the car reaches them if approach is made at normal slow speed

indicated the presence of a large number of ultrasonic frequencies which were not of great strength at any one frequency, but gave small responses at a multitude of frequencies in the range of approximately 18,000 to 40,000 cycles.

A second tuned coil, generally tuned to a higher frequency than the desired signal, is inserted in the discriminator circuit. Any signals received in this circuit are rectified and delivered as positive voltages to the relay circuit. If an undesired ultrasonic signal is received at the discriminator circuit which contains a multitude of frequencies as generated by the above-mentioned ultrasonic sources, the resultant d-c output will be zero or predominantly positive, depending on the frequency distribution, and the relay will not operate. The relay tube circuit is thus operative only when a negative voltage of proper amplitude is applied to the grid.

The d-c voltage obtained from the discriminator circuit is applied to the grid of a two-stage double-triode relay control tube. Contained within this circuit is a time-delay network which closes the relay contacts after approximately three seconds of steady signal reception. This time delay is necessary to prevent door operation by transient ultrasonic waves and sudden line voltage surges.

The relay used in the control has a low armature release point, being generally 50 percent of the pull-in value. This is required because in field installations a large drop in line voltage occurs when the motor operating the doors is running on the starter winding. This drop in some cases reduces the line voltage from 120 volts to as low as 80 volts for a short instant.

Choice of Generator

Various methods of generating ultrasonic waves were investigated

Ultrasonic

By BOLEY A. ANDREWS

Engineering Department
The Vendo Company
Kansas City, Missouri

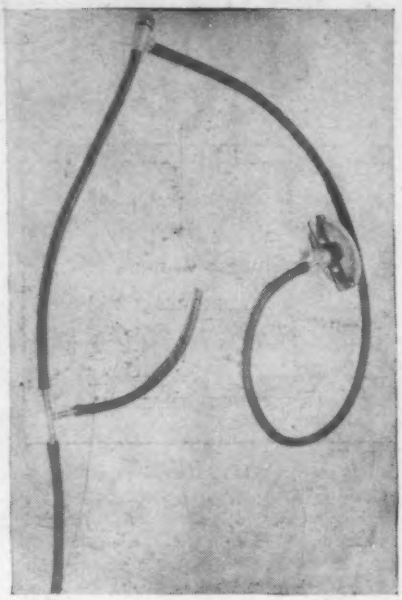
THE control system described here utilizes sounds above the audible frequency range for the purpose of actuating motor-operated garage doors from a remote position, such as from an automobile approaching the garage. The system consists essentially of an ultrasonic generator mounted on an automobile, an electronic amplifier and relay system mounted in the garage directly above the doors, and a microphone installed outside of the garage.

Ultrasonic Whistle

The ultrasonic generator used in the system consists of a vacuum-operated whistle, mounted together with a reflector directly behind the front grille of an automobile. The reflector concentrates the ultrasonic wave directly forward and protects the whistle from rain, snow, and any foreign objects which might obstruct the sound orifice.

The whistle is connected to the vacuum system of the vehicle by means of a rubber hose, and is turned off and on by an air valve clamped to the dashboard. The connection to the vacuum system is generally made at the windshield wiper mechanism by the insertion of a T pipe between the main vacuum line and the windshield wiper and vacuum whistle hose line. When an electric windshield wiper is used on a car, the vacuum connection is made at the intake manifold after installing a suitable fitting.

The amplifier circuit combination necessary for satisfactory operation is given in Fig. 1. A voltage amplifier is followed by a triode which serves as a limiter. Limiter action takes place with input voltages of 7 mv and over. The limiter is necessary because it is desirable to introduce into the discriminator tube circuit a constant voltage regardless of signal intensity variations which can be caused by such conditions as the position of the automobile, wind velocity and direction, and any other factors which may tend to increase or decrease the ultrasonic intensity.



Ultrasonic generator shown here is only item installed on car. Pushbutton valve at top is mounted on dashboard, and ultrasonic whistle at right is installed behind radiator grille. Unattached lengths of hose here are part of original windshield wiper line on car

The amplified and limited signal is fed into a discriminator circuit which selects the desired signal frequency, rectifies it, and places a negative d-c bias on the grid of the first triode section of the following relay circuit, so that the second triode section operates the relay whose contacts control the door-opening mechanism. The discriminator also protects the control system from operation by unwanted ultrasonic sources.

Experiments and tests indicated that ultrasonic waves can be produced by such sources as jingling of keys and coins, rustling of tissue or cellophane, and the release of compressed air through a small jet. Analysis of these sounds by means of heterodyne ultrasonic detectors

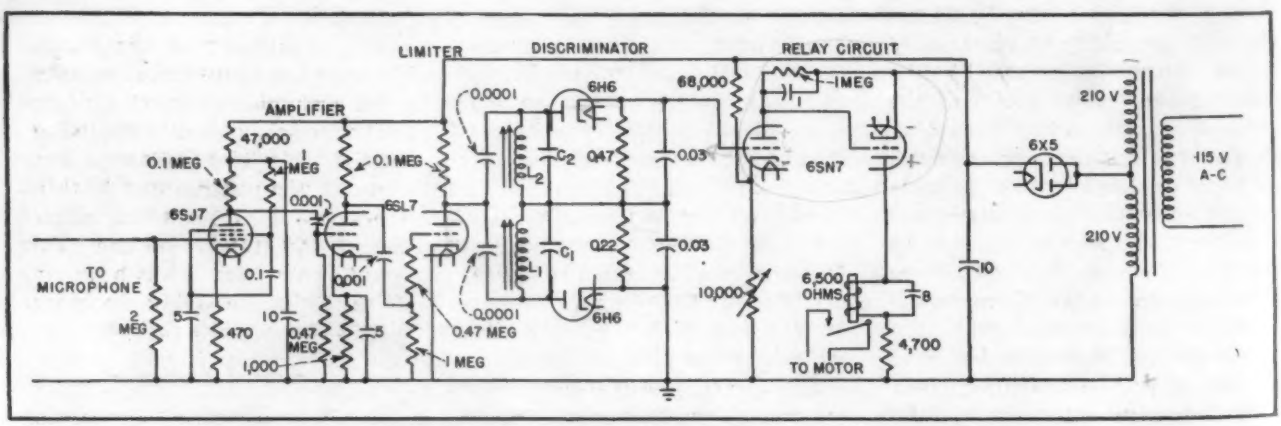
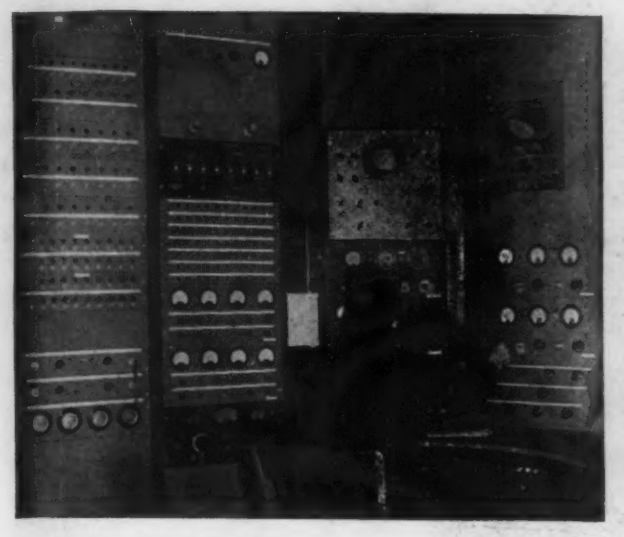


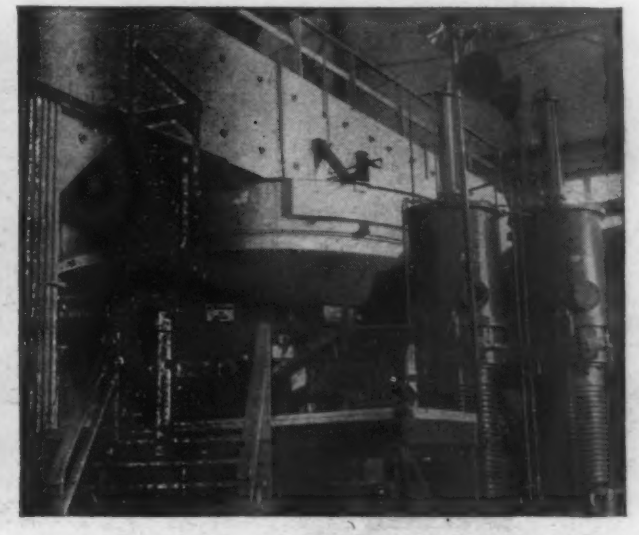
FIG. 1—Complete circuit of amplifier used in supersonic door-opening system

F-M CYCLOTRON

Operating at about 10 mc and to be used in atomic energy research, world's largest cyclotron accelerates electrons to energies comparable to those of cosmic rays



At main control position are vacuum gages, interlock lights, vacuum-pump flow sheet, shortwave receiver for monitoring oscillator, and oscilloscopes showing oscillator frequency and dee potential against time

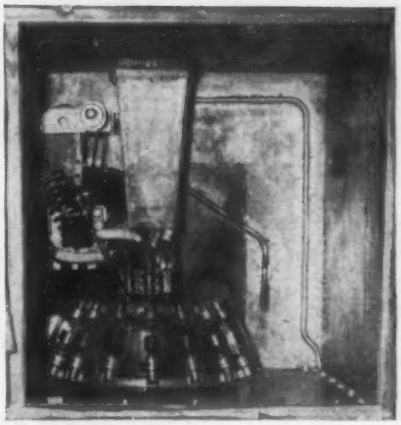


Pole faces of cyclotron are slightly more than 15 ft. in diameter. Electromagnet has 3,700 tons of steel in core, 300 tons of copper in winding, consumes 500 to 600 kw excitation. Gap is 20 in. wide

GIANT CYCLOTRON at University of California uses a frequency-modulation principle to accelerate electrons to 200 million electron volts. Protons (hydrogen nuclei) can be accelerated to 350 mev, alpha particles (helium nuclei) to 400 mev, deuterons (heavy hydrogen nuclei) to 200 mev.

Electrically charged particles that are to be accelerated are projected into the 1,600 cu ft accelerating chamber, which is between the pole faces of the magnet, and is maintained at a vacuum of a millionth of a millimeter of mercury by five stages of diffusion pumping followed by a mechanical pumping stage.

Charged particles, in circling the chamber, pass the gap between the half drums (dees). A peak potential of 50,000 volts across this gap accelerates the particles as they pass from the left dee to the right one. After half a revolution, the particles return from the right dee to the left one, being again accelerated because the potential between the dees has reversd polarity. As the electrons move faster they travel in larger spirals and, because of their relativistic increase in mass (they circle the chamber about 10,000 times a millisecond), at lower angular velocities. They thus transit the gap late in the cycle and are not accelerated. To compensate for this phase defect, the frequency at which the potential across the dees is reversed is lowered.



Grounded-grid oscillator using water-cooled 9C21, the leads of which can be seen projecting above ring of vacuum capacitors that ground the grid, dissipates 50 kw at plate. Rectifier in grid circuit, not shown, stops damaging grid emission

In this cyclotron the oscillator used to charge the dees is frequency modulated at 120 cps between 12.5 and 8.17 mc by a vacuum capacitor with 24 teeth on its rotor passing at 300 rpm between forked projections at the end of the parallel-wire resonant line. The change in capacitance loading on the line changes its resonant frequency. Charged particles are accelerated during the half of the modulation cycle for which the oscillator frequency is decreasing.—F.R.

before the final development of a vacuum whistle for this purpose. The first method considered was the use of quartz crystals similar to those used in underwater signaling. While this method was satisfactory for underwater use, the acoustical difference between quartz and air proved too great for efficient sound generation in air. The associated electronic oscillator equipment required in conjunction with the quartz transducer also proved too cumbersome and costly.

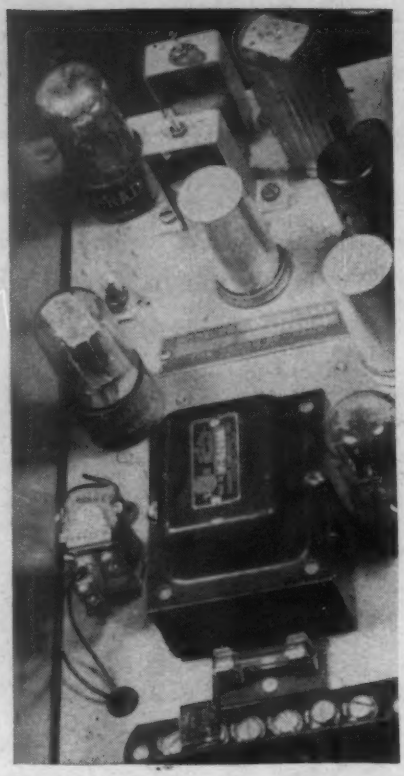
The second method involved a magnetostriction oscillator using a nickel rod with an attached piston. This system, as in the case of the quartz transducer, required an electron oscillator and was very inefficient when using air as the medium of transmission.

A third method used a pressure-operated air whistle constructed similar to a Galton whistle. The frequency of this whistle was determined by the size of a resonant cavity which was placed directly in front of an air orifice.

The intensity of the ultrasonic waves produced by the pressure-type ultrasonic whistle was satisfactory, but the frequency of the whistle varied greatly with air pressure. Since this whistle was pressure-sensitive, and the only source of air pressure was from a cylinder of the vehicle on the compression stroke, an air regulator would be required to smooth over the air pressure. This would have been too costly and cumbersome.

Whistle Design Data

A vacuum-type ultrasonic whistle was developed, and is now being used with good results. As shown in Fig. 2, the whistle is composed of three important parts, an air orifice, a resonant cavity, and a vacuum connection. The wavelength corresponds very nearly to the natural frequency of the cavity, which can be calculated from $\lambda/4 = L + 0.3\ d$, where L is the depth and d the diameter of the resonant cavity in millimeters, and λ is the wavelength in meters. For the best results the depth of the cavity should not exceed twice its diameter.



Amplifier unit used inside garage

In operation, the air is drawn through an orifice and the resultant air jet is projected into the mouth of a cavity, which is generally drilled to a dimension which is one-quarter wavelength at the desired sound frequency. Whistles have been constructed experimentally from a frequency as low as 5,000 cycles to as high as 45,000 cycles. Frequencies above 20,000 cycles are being used for this particular door control application.

Several interesting facts were noted while this whistle was under development. Tests indicated that no appreciable change in frequency was encountered when using a given whistle on various vehicles which had vacuum readings varying from 15 to 19 inches. The whistle was still operative even when the windshield wiper was operated simultaneously with the ultrasonic whistle.

A change in frequency is noted when the ultrasonic whistle system is subjected to ambient temperatures. This is caused by the fact that the velocity of sound in air changes with temperature. The velocity of sound in air at any temperature t in degrees C is $1{,}087.5 + 1.97t$ feet per second. The increase in velocity per degree centigrade temperature rise is approximately 2 feet per second. Because of this change in velocity it was necessary to provide a bandwidth of frequency response in order to obtain satisfactory operation despite atmospheric temperature changes.

The microphone used with this system consists of a duralumin diaphragm to which is cemented a type PN resonant crystal. This crystal is an improvement over the Rochelle-salt type crystal in that it will withstand high temperatures such as are encountered in full summer sunlight without losing its sensitivity. The diaphragm is suspended in such a manner that it can vibrate freely at ultrasonic frequencies, the size of the diaphragm being varied according to the actual frequency employed.

Ultrasonic control as described in this article can also be used for other control purposes. The present application seems to be most apropos, however, since the vacuum generator is readily applied to an automobile and the general public is keyed up for postwar electronic pushbutton apparatus.

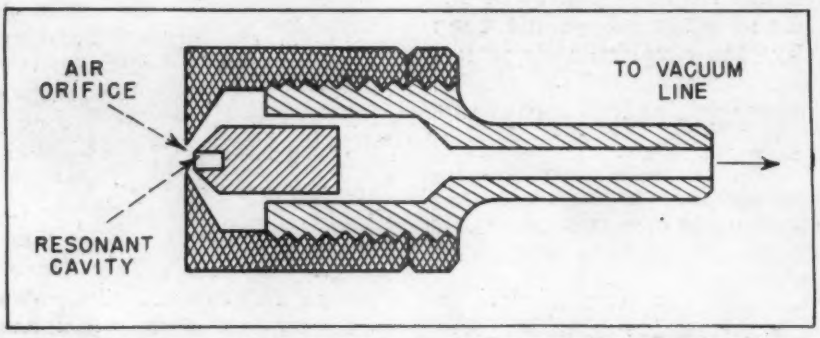
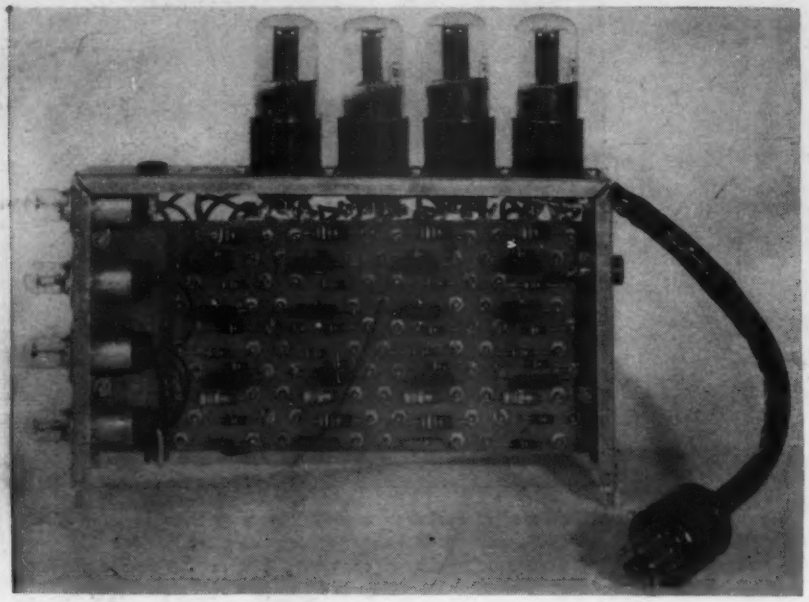


FIG. 2—Cross-section of ultrasonic generator used on automobile. Air gap between orifice and resonant cavity is adjusted for high signal intensity and entire assembly is then locked and soldered

Predetermined Counters

Banks of ten-position switches permit setting electronic counter decades to actuate a relay after any desired total count. Industrial uses include batching, counting, timing, controlling zipper-making machines, and automatic packaging of pills



Complete four-tube counter decade, which delivers one output pulse for every ten input pulses

WITH the ever-increasing use of high-speed industrial processes and operations there has developed a great need for control, counting, sorting, and packaging equipment to keep pace with highly efficient manufacturing standards. To meet this need there are now available high-speed predetermined counters which can be used for automatic control of machinery.

Mechanically operated counters have their limitations in the maximum speed at which they can count (usually less than 10 per second) and the fact that they are usually actuated by the operation of a machine rather than by a processed item. Therefore the counter continues to register even if the machine runs out of stock or fails to operate correctly.

The predetermined counter to be described can readily be used to count, sort, or group for packaging any small or large items at rates up to 15,000 per minute in predetermined quantities from 1 to 10,000 or more pieces. Some of the products which could be so counted are pills, buttons, screws, washers, caps, sheet steel, machined parts, and even liquids.

By way of illustration, consider the application in counting and grouping of pills for packaging. Figure 1 indicates how a predetermined counter is used to count a definite number of pills and accurately channel the quantities into two lines of bottles on a moving conveyor belt. Pills to be packaged are placed in a hopper and are fed to a rotating disc and belt arrangement which is designed to emit pills in single file at rates of approximately 250 per second. As the pills pass through the light beam they cause impulses, representative of quantity, to be injected into the input of the predetermined counter.

Assuming that the desired quantity in each bottle is 100, the counter is set by means of dials to actuate a self-contained high-speed single-pole double-throw relay each time a count of 100 is reached. The output of this relay actuates a solenoid which moves a deflector plate and thereby channels the pills in quantities of 100 alternately through two duct channels. The conveyor belt carries the empty bottles in two lines to gates which are directly under the ducts. These gates are actuated alternately by the same impulses which control the deflector plate. When each bottle has been filled with the correct quantity of pills the respective gate is opened and the bottle is permitted to travel along the conveyor to the capper.

Single Predetermined Counters

The basic unit of the predetermined counter is the four-tube counter decade described in detail in June 1944 ELECTRONICS, p 110, which will register a count from 1 to 9 on neon bulbs and then reset to 0, and will provide one output pulse for every 10 input pulses which are injected. This is accomplished in a binary progression using a 1-2-4-8 series.

The single predetermined counter consists of four such decades in tandem, four wafer preset switches for setting the predetermined count, and an electronic switch which is used to actuate a double-pole single-throw output relay. The block diagram in Fig. 2 indicates how these parts are functionally connected together. By using the four decades a count of 0 to 10,000

By JOHN J. WILD
Potter Instrument Co.
Flushing, New York

can be predetermined simply by setting the four dial switches (each having ten positions numbered 0 to 9) to the complement of the desired number. In other words, if an operation is required to take place at 3333 counts, the number which is set up by means of the dial would be 6667. The addition of 3333 counts to the preset number of 6667 makes 10,000, which is the maximum count of the instrument and therefore actuates the electronic switch for control of the operation. In the case of the pill counter described previously, the count of 100 was achieved by setting the dial switches to 9900.

The dial wafer-type switches serve to make connections to the proper grids of the trigger tubes, for injection of the pulses needed to give a predetermined starting count. One four-layer wafer-type switch is required for each decade, with connections as shown in Fig. 3. The preset combination of pulses can be applied automatically at the end of each count to the common terminals of all switches, or manually by means of the preset button located on the front panel.

When automatic preset is used, the output pulse from the last decade is used to trigger a pulse generator which supplies a positive pulse to the required grids for starting a new count, as determined by the setting of the preset switches. Manual preset is accomplished by closing the preset switch, which injects a positive pulse to the selected grids as in the automatic reset.

The electronic switch which controls the position of the double-pole single-throw output relay is another double-triode trigger stage with a neon indicator lamp in each plate circuit. At the end of each predetermined count these two trigger stages are alternately switched from conducting to non-

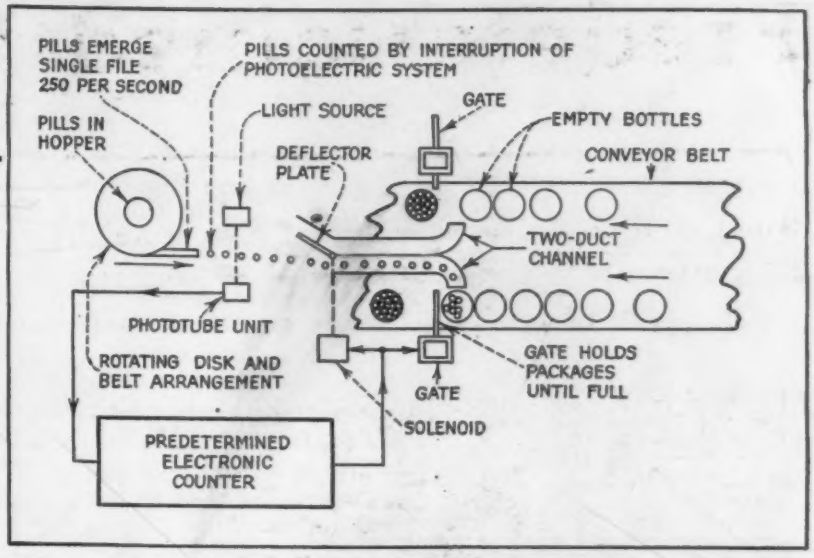


FIG. 1—Method of using single predetermined electronic counter for counting pills at rate of 15,000 per minute and placing exactly the correct number automatically in each bottle on the conveyor belt

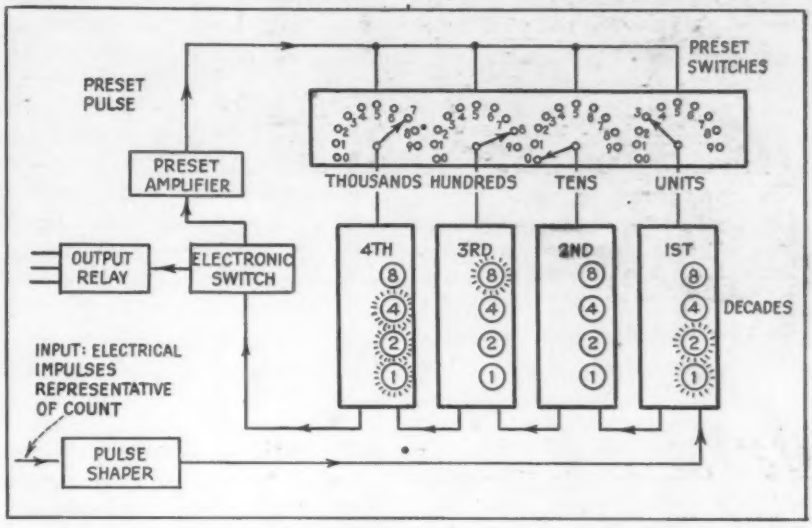


FIG. 2—Block diagram of four-decade single predetermined counter, showing switches and lamps set for starting count of 7803 as required for batching of 2197 units

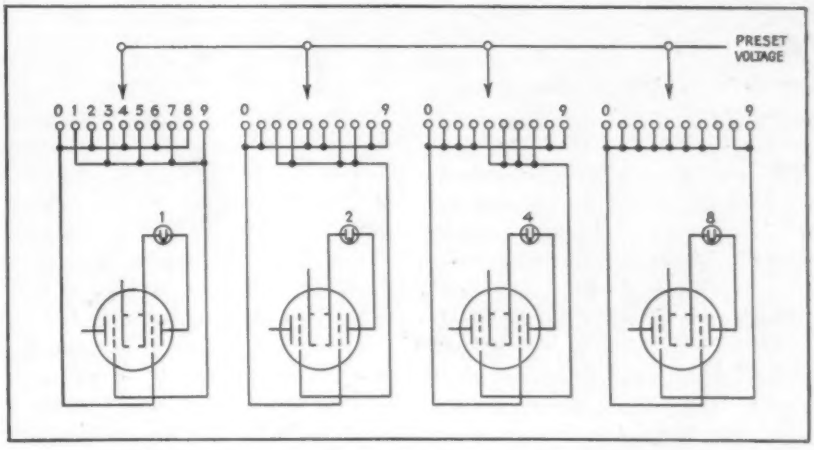


FIG. 3—Switching circuit used for selection of predetermined count on one decade

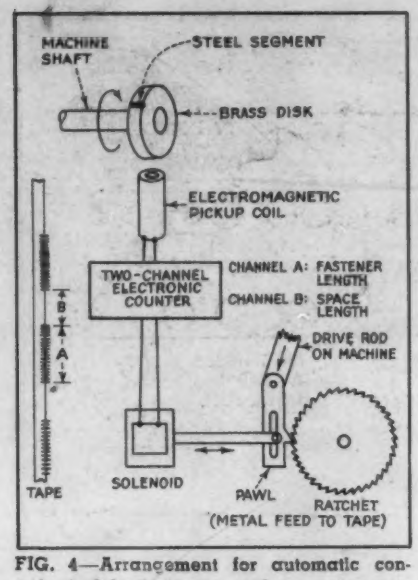


FIG. 4—Arrangement for automatic control of slide fastener machine, using one predetermined channel to control the number of elements inserted in the fastener tape and using the second predetermined channel to control the spacing between sections on the tape

conducting, thereby controlling the output relay and the neon indicating lamps.

The predetermined counter is easily applied to all types of operations and processes requiring split-second control. The input impulses may be derived from a shaft rotation, the interruption of a photoelectric light beam, reciprocating member motion, contact closures, electromagnetic field disturbance, and many other actions which are representative of counts. The fast-acting output relay can readily be adapted for solenoid control.

Dual Predetermined Counters

Dual predetermined counters may be used for controlling processes which consist of two different operations. An example of this type of application is high-speed control of zipper manufacture, illustrated in Fig. 4. The problem is to control accurately the number of metal elements and the spacing between groups of elements inserted in the continuously moving tape. These two operations are normally controlled by cams or gears, which frequently cause errors and limit the maximum speed of operation.

Since the dual predetermined counter is designed to provide alternate switching of the output relay at the completion of each of two different predetermined counts, this instrument can be readily substituted for the cam or gear control in this application. In practice the number of zipper elements desired is set up in one channel of the counter by means of the dial switches, and the spacing between the groups of zippers is set up in the other counter channel by means of a second row of dial switches. The input to the counter is derived from a shaft rotation which corresponds to the insertion of a zipper segment or to an equivalent space on the fastener tape.

With existing types of zipper machines it is necessary to change gears or cams each time a new fastener length is desired. By using a dual predetermined counter for control, this time-consuming operation is eliminated. To change fastener length with the electronic control it is necessary to change only the dial switch settings, which can be accomplished without stopping the machine.

The dual predetermined counter employs one additional preset switch channel and amplifier, as indicated in Fig. 5. It can be used to control any two-step continuous operation by actuating a control at the completion of each of two predetermined counts or time intervals. Normally this model will control at rates up to 12,000 per minute. Equipments suitable for higher rates of operation are also available.

Applications

For accurate counting at high speeds, standard counters using the decade system described will operate at rates up to a million per second in response to interruption of a photoelectric light beam, closing of contacts, or to any other type of actuator.

Predetermined counters are finding wide usage in high-speed packaging and sorting applications, as well as in high-speed manufacturing processes which require split-second actuation of controls. This type of counter is now being used in the manufacture of zippers, control of tin plate processing, packaging of many different types of small items, and hundreds of other industrial applications.

When used as an interval timer, a crystal-controlled oscillator is fed into the counter by an electronic

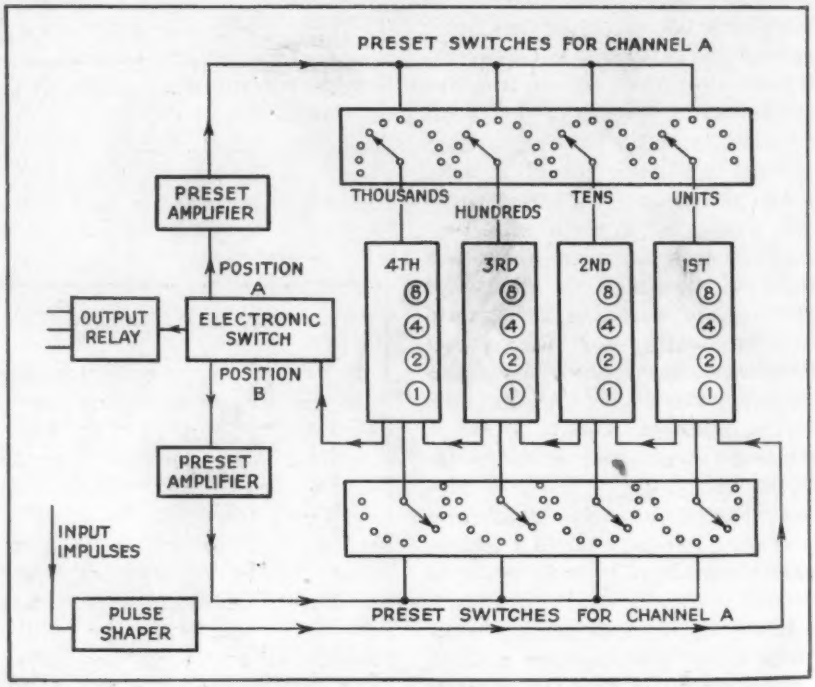
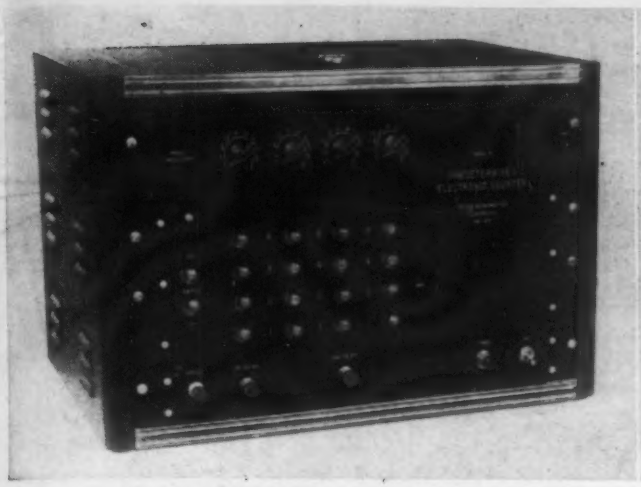


FIG. 5—Block diagram of dual predetermined counter used for high-speed control of two different operations that occur in sequence and recycle continuously



Single predetermined electronic counter, using four counter decades and one bank of presetting switches

Dual predetermined electronic counter, with two banks of presetting switches alternately controlling the decades

switch or gate which is operated by the initiating and terminating pulses from a time interval. If a 100-kc crystal is used as the standard, the accuracy of measurement will be +0 and −10 microseconds for an interval as long as desired. In units using 400-mc or 1.6-mc oscillators, the accuracy is +0 and −1 cycle of the respective crystal frequencies. These interval timers are now in use by the armed services for projectile velocity measurements.

Preset interval timers using the same principles as the predetermined counters are also being supplied for the generation of precise time intervals which are selected by means of dial switches.

Totalizing

An instrument has been developed which is capable of totalizing the individual outputs of many sources occurring at random times. This system has already been applied to a pari-mutuel betting machine at a race track for recording the amount of money bet on each horse at the ticket machines. Since this equipment must also convert the $2, $5, $10, and $50 bets into equivalent dollars for totalizing, it was necessary to develop circuits which would add and multiply electronically.

In a manufacturing process where many machines are making the same product at varying rates, it is often desirable to know the total output or the average rate per machine. The totalizator equipment can be readily used for this purpose even where the outputs occur at random rates and counts occur simultaneously.

This system can be easily applied to newspaper plants for obtaining an up-to-the-second count of the various press outputs. It can also be used to record total fluid output by totalizing the outputs of the individual flowmeters. Power plants can use such a device for recording the total output from several generators by totaling the readings of the individual wattmeters. These are but a few of the thousands of possible applications of totalizator equipment.

The basic part of most calculators is a mechanical counter decade. Substitution of electronic counters will give much greater speed and may provide a less expensive method of adding, subtracting, dividing, and multiplying, especially in business uses.

Although not specifically designed for the purpose, the predetermined type of counter described is in reality a dividing device. In this case the number of impulses injected at the input is the dividend, the complement of the number set by the dial switches is the divisor, and the number of output pulses is the quotient. The totalizing circuits mentioned are inherently multiplying and adding devices.

The electronic counter offers a method of increasing the rate of circuit selection, now generally accomplished by stepping relays as in dial-telephone operation. A series of rapid pulses may be transmitted over a line for almost instantaneous selection of a desired circuit. By the use of totalizing counter circuits mentioned previously, these pulses may even occur simultaneously.

Counter circuits may also be used in the many places where frequency dividers are required. A distinct advantage is the fact that the divider stops when the control frequency stops. The input control frequency may be varied from 100 kc down to zero and the same division rate will be accurately maintained. The counter circuit used as a frequency divider is highly desirable in television pulse generator circuits because of its stability and absolute division rate.

By use of the predetermining features described, it is possible to divide any input frequency by any factor established by means of predetermined dial switch settings.

When used as scaling circuits and counters in radiation work, decades with a resolving time of 0.00001 second are available. Counters having a resolving time of 0.000002 or higher can also be supplied. A distinct advantage in using this type of decade is decimal registration of the count, not available in other types of radiation counters.

Pulse Modulated C

Method and circuits are presented for pulsing a high frequency oscillator so that all waves are of the same amplitude. Pulse rate is variable over wide limits independently of oscillator frequency. Calibration and marking of sweeps with the equipment are described

AN IMPROVED METHOD for generating a train of sine waves, in which the first cycle is identical to the following cycles, is described. The train may be initiated from an outside trigger and may therefore operate over a wide range of pulse repetition frequency. Large peak-to-peak amplitudes are available requiring but small power input.

Rapid development of equipments utilizing pulse techniques has made necessary precise methods of time measurement. The cathode-ray oscilloscope using slave sweeps has become a common tool for accurate pulse work[1, 2, 3, 4].

Various means have been suggested for calibration of time bases[5, 6, 7]. The method described in this paper provides a readily adjustable means of generating a sinusoidal wave train of uniform amplitude under control initiated by externally applied triggers.

Pulsed Resonant Circuit

The most elementary type of sine wave sweep calibrator is shown in Fig. 1A. Operation depends on the transient oscillation which results from sudden interruption of a steady current flowing through an inductance shunted by a capacitance. Should the current I_p be suddenly cut off by application of a negative gate to the triode grid, an oscillatory voltage appears across the capacitance such that

$$e_c = -I_p(L/C)^{1/2}\epsilon^{-\omega t/2Q}\sin\omega t \qquad (1)$$

where the symbols are defined and derived in the appendix.

The exponential term of Eq. 1 determines the rate of decay of the oscillation. If Q were very high, oscillations would persist, dying out gradually. However, with ordinary commercial inductors having practical values of Q, oscillations decay in a relatively short time, as shown in Fig. 1B.

The magnitude of Q required to give an amplitude Ke_0 to the nth cycle of oscillation (derived in appendix) is

$$Q = \frac{\pi(n-1)\pi}{\ln(1/K)} \qquad (2)$$

Thus to obtain e_n equal to $0.9e_0$ that is K equals 0.9, where n is 21 cycles, Q must nearly equal 600 (This relation incidentally provides a method of measuring Q of an inductor[8].)

Limitations of the damped train as an accurate source of sweep calibration markers are numerous and some superior means have been developed.

Keyed Oscillator

It is possible to develop a sine wave train by the method shown in Fig. 1C. A Hartley type oscillator is connected so that application of a positive gate to the triode plate will result in the growth of oscillations such that

$$i = (e_s/\omega L)(\sin\omega t)\exp R_n t/2L \qquad (3)$$

Oscillations grow at a rate determined by the magnitude of negative resistance R_n introduced by the oscillator tube. This circuit may be difficult to synchronize well. The degree of synchronization depends upon factor e_s of Eq. 3. If sufficiently high frequency components are present in the rising edge of the positive gating pulse, synchronizing pulses can be obtained in the tuned circuit through the triode grid-to-plate capacitance. At best, locking with the trigger is precarious and, in addition, time de-

CHARACTERISTICS

The method described in this paper for generating a recurrent finite train of sine waves has the following characteristics:

Wave train may be initiated by an external trigger

First cycle of the sweep marker train has the same amplitude as succeeding cycles

Any number of cycles in the train may be produced by adjustment of a single control

First cycle is delayed by less than half a microsecond with respect to the trigger pulse

Frequency of waves in the train can be 20 mc and higher and still have sufficient amplitude for direct deflection of a five-inch cathode-ray tube beam or for direct intensity modulation

Plate current consumption of the generator circuit proper can be less than ten milliamperes at 150 volts

Frequency of the waves in the train may be continuously variable over a wide frequency range by simple adjustment

Oscillator

By ALLAN EASTON

Special Products Division
Emerson Radio and Phonograph Corp.
New York, N. Y.

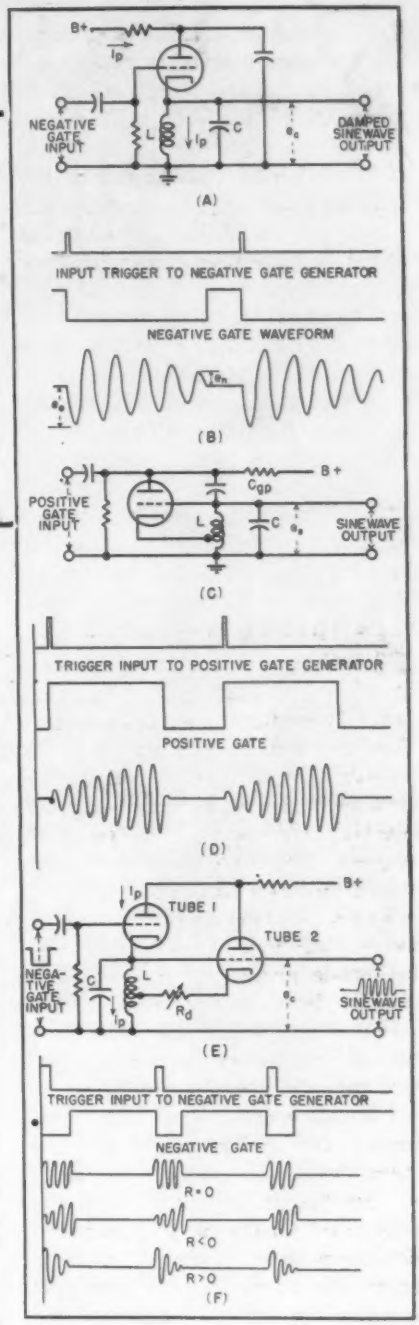


FIG. 1—By combining a pulsed resonant circuit (A) giving a damped wave train (B) with a keyed oscillator (C) giving a wave train that builds up, (D), a pulsed oscillator (E) that can generate a wave train of constant amplitude (F) is obtained

lay involved in waiting for oscillations to reach final amplitude, as illustrated in Fig. 1D, may be prohibitive for many applications.

Combination Circuits

An ingenious combination of both circuits described above was developed by Radiation Laboratory, Massachusetts Institute of Technology.

The circuit, shown in Fig. 1E, may be analyzed qualitatively by considering the oscillator tube (tube 2) as a source of negative resistance. If the oscillator were not present, the circuit would be similar to that of Fig. 1A, the damping resistance in this case is greater than zero and therefore the wave train will decay exponentially as mentioned. As the magnitude of the negative resistance (controllable by degeneration potentiometer R_d) causes the equivalent circuit resistance to approach zero (Q approaches infinity), the envelope of the oscillations more nearly approaches a pair of parallel horizontal straight lines. Should the effective circuit resistance become negative, oscillations will build up from their initial value to some final value determined by circuit parameters. These conditions are illustrated in Fig. 1F.

The magnitude of the peak voltage of the first cycle is

$$e_{max} = I_p(L/C)^{1/2} \qquad (4)$$

Equation 4 predicts an oscillator voltage proportional to the d-c plate current and to the square root of the L to C ratio. Substituting typical values into the equation where $C=100\mu\mu f$, $L=250\mu h$, $I_p=0.010$ amp, and $f=1.006$ mc gives e_c equal to 15.8 volts peak or 31.6 volts peak-to-peak.

If this voltage is inadequate for a particular application, it is then necessary to increase I_p. The upper limit to the L to C ratio is determined by stability requirements and therefore cannot be increased indefinitely.

At about 10 mc this circuit becomes expensive and unwieldy. Suppose $C=25\mu\mu f$, $L=10\mu h$, $I_p=0.010$ amp, and $f=10.06$ mc, then e_c is equal to 6.32 volts peak. To obtain the same value of e_c at 10 mc as was realized at one megacycle, plate current should be more than doubled and yet circuit stability would be poorer because of the higher L to C ratio. Should really large marker voltages be desired, excessive plate currents would be required.

Pulsed Oscillator

For reasons of economy and simplicity another approach to the problem, which extends the operating range to well over twenty megacycles, was tried. The principal difference circuitwise is the inclusion of a gas thyratron such as a type 2D21, 2050, 6D4, or 884 and associated circuits shown in Fig. 2.

Theory of operation is as follows. Three tubes are employed, a shock tube V1, a clamp tube V2, and an oscillator tube V3. The shock tube V1 has the characteristic of being able to pass large surges of current (in excess of five amperes) for a short interval and then remain in the ready state with the passage of a small current (in the order

of microamperes). Clamp tube V2 has the characteristic that its resistive impedance from cathode to ground (the plate is held at a-c ground by a capacitor), which is in parallel with the tuning coil of the oscillator, is very high when the tube is nonconducting (control grid biased negative), and very low (about 300 ohms or less depending on tube type) when the tube is conducting. Oscillator tube V3, with its circuit, is permitted to oscillate or prevented from oscillating by the clamp tube by virtue of the tube resistance which shunts the tuned circuit.

In operation the circuit is in the ready state when C_2 is fully charged through R_3 to the supply potential. Tube V2 is conducting and tube V3 is therefore in the nonoscillating condition.

Sequence of Circuit Functions

When it is desired to set off a train of oscillations each of the same amplitude, a sharp positive pulse is applied to the thyratron grid through R_1C_1, causing the gas to ionize and C_2 to discharge through the interelectrode space and the primary of the high frequency transformer. Simultaneously with the positive pulse on the thyratron grid, a negative gate is applied to the grid of the clamp tube through C_3R_4 causing the clamp tube to become nonconducting and permitting oscillations to build up.

Oscillations will, therefore, not have to build from low amplitude gradually, but can be equal or even larger than succeeding oscillations.

When the positive pulse which was impressed on the thyratron grid decays, the gas tube deionizes by virtue of R_2C_2 in the plate circuit, and the tube disconnects itself from the circuit except for the cathode to ground capacitance across the tuned circuit. Oscillations will continue until the negative gate on the clamp tube grid is removed, permitting the clamp tube to become conducting thereby quickly damping the oscillations.

Rate of decay is determined by the magnitude of the resistance the clamp tube shunts across the tuned circuit. Type 6J4 which has a very high value of transconductance will damp the oscillations faster than will type 6C4. (In all cases decay time may be longer than rise time.) Meanwhile C_2 will be recharging through R_3 preparatory for the next cycle of operation.

Circuit Characteristics

This circuit has been constructed and tested using component values indicated in Fig. 2. With a positive plate voltage supply of 150 volts, it was possible to obtain as much as 80 volts peak to peak at 20 mc. This large voltage was possible chiefly by virtue of the tremendous surge of current delivered by C_2 through the thyratron tube into the tuned circuit as explained above. The circuit as shown is capable of operation at pulse repetition frequencies ranging from less than one cycle per second to slightly over 5,000 cps. Total average plate current consumption of the three tubes does not exceed ten milliamperes at the highest frequency of operation.

Some necessary precautions for obtaining optimum performance are:

The positive trigger which actuates the thyratron grid should have a steep rise, preferably in the order of 1,000 volts per microsecond.

The negative gate which actuates the clamp tube must rise quickly enough so that the clamp tube current is cut off at the same time that the gas tube fires.

The transformer primary must be connected to the cathode of the shock tube by short leads. The primary must be closely coupled to the secondary; the primary turns numbering one half of the secondary turns, approximately.

R_7 is adjusted for flattest topped wave trains.

R_2 should be selected of sufficient resistance to limit peak current in the thyratron to a safe value as specified by the manufacturer. R_2 may be used to determine the initial amplitude of the generated sine wave train.

Applications

The most obvious application of the pulse modulated oscillator is for time base calibration. In the commonest case a saw-tooth sweep of somewhat indeterminate length is used to measure characteristics of a pulse display. The sine wave train is fed into vertical deflecting plates of a cathode-ray tube and horizontal deflection sensitivity is adjusted to give a full deflection. Thus with the period of the calibrating waves known, the time scale in microseconds per inch is determined. Calibrating markers are virtually indispensable where the sweep velocity is not constant.

The pulse to be measured may be observed simultaneously with the calibrating markers. Controllable delay and negative gate duration may be adjusted to cause the markers to coincide with the pulse.

Intensity grid modulation of the cathode-ray beam is a popular means of utilizing sweep markers. The sine wave train may be mixed

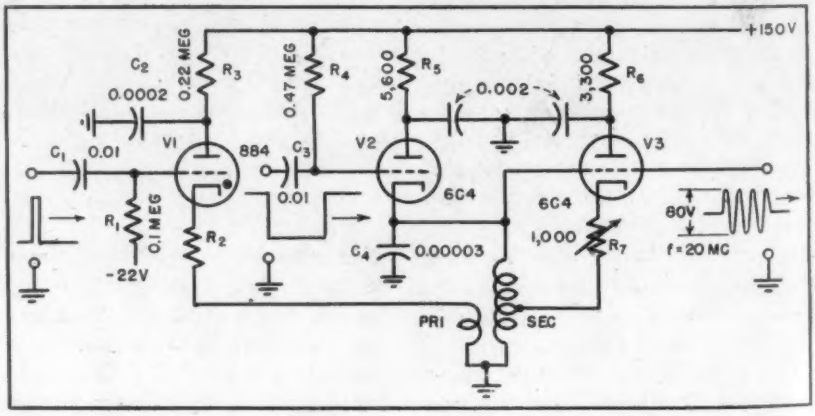


FIG. 2—Circuit of a pulsed oscillator that delivers pulses of high, uniform amplitude

with blanking pulses or may be connected to the cathode or grid of the cathode-ray tube while the blanking pulses are connected to the unused element. Alternate bright and dark spots facilitate measurement of pulses without distorting the shape of the display.

A convenient possibility is to use one pulsed oscillator for making one microsecond dots and another for making 0.1 or 0.05 microsecond dots and then mixing the two to give marker dots.

A particularly interesting extension of testing amplifiers by square wave analysis[9] is made possible with the pulse modulated oscillator. In present television receiver practice an intermediate frequency of about 21 mc has been accepted as standard. Overall bandwidths of 3 to 5 mc are used and some means for testing transient response of intermediate frequency amplifiers is needed. It is customary to use a sweep oscillator and cathode-ray oscilloscope[10] for this purpose. This method gives little information concerning transient response whereas the pulse modulated oscillator when injected into the grid circuit of the i-f amplifier enables direct observation of pulse response of all circuits after the mixer. Vertical or horizontal synchronization pulses can be used to trigger the pulsed oscillator.

Methods of Calibration

In order to utilize fully the pulse modulated oscillator, some means of accurately setting or measuring the sine wave frequency is needed.

Common is the zero beat method in which a crystal oscillator or standard signal generator is made to zero beat with the unknown frequency. Caution must be maintained to avoid synchronization of the pulsed oscillator by the standard frequency source or the reverse. It is possible for the pulsed oscillator to begin oscillating at a frequency determined by its own circuit constants and then be forced into another frequency of oscillation by the calibrating voltage. At 20 mc, small stray capacitances may cause considerable coupling. Synchronization of either pulsed

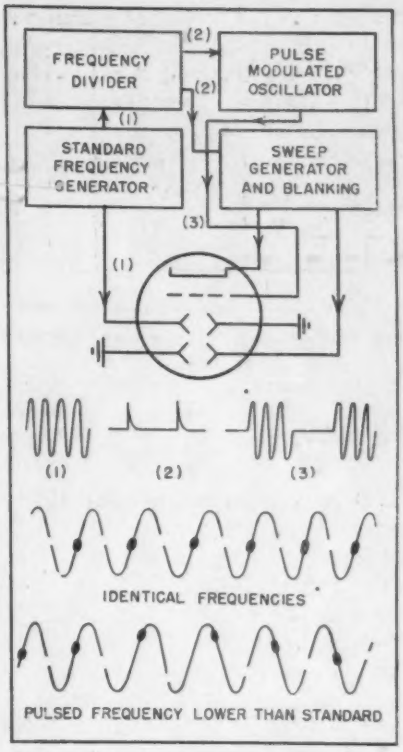


FIG. 3—Using the method shown at the top, the patterns shown below are obtained to indicate the frequency of the pulsed oscillator

oscillator or calibrating oscillator by one another or by an external stray signal must be avoided if useful results are to be obtained[11]. The zero beat method gives no information about the spacing of individual sine waves of the pulsed train but measures average frequency. If the first few oscillations had a different period from the succeeding cycles, a situation which is quite possible, the zero beat method would not reveal this fact.

The fact that the sine wave train is pulsed, that is, interrupted periodically, gives rise to a spectrum of frequencies, any one of which may give zero beat with a calibrating frequency. Only one of these beats represents the center frequency of the wave train[12].

Another method of calibration utilizes the cathode-ray tube oscilloscope to obtain a Lissajou figure[13]. When two voltages of slightly different frequencies are compared, one connected to each pair of deflecting plates of the cathode-ray tube, a stationary pattern will appear either if the two frequencies bear a harmonic relationship, or if they have a harmonic in common.

When the two frequencies are equal, a stationary geometric figure such as a circle, ellipse, or straight line can be obtained. The same precautions against unwanted synchronization must be observed in this case. The characteristic circle denoting equal frequencies can be obtained by comparing the calibrating frequency with any one of the spectral sideband components of the pulsed wave. Frequency difference between successive spectral components depends upon pulse repetition frequency. Advantage may be taken of this fact in calibrating by Lissajou figures. If the characteristic circle is obtained, change the pulse rate slightly; only the center component, that is the nominal sine wave frequency, will remain unchanged and will continue to give the circle. Any spectral sideband components will change frequency when the pulse rate is altered.

An excellent method of calibration, first demonstrated to the author by R. D. Scheldorf of Radio Corporation of America, is illustrated in Fig. 3. A crystal oscillator or other type of standard frequency generator is connected to a frequency divider which generates a synchronizing pulse to trigger the pulse modulated oscillator and slave sweep of the cathode-ray oscilloscope. The standard frequency voltage is connected to the vertical plates through the vertical amplifier, and the pulse modulated oscillator to the intensity control grid (Z axis). If the two frequencies differ but slightly, a very easily recognized result appears. The difference frequency shows up as a wave of bright spots whose period is equal to the reciprocal of the difference. Precautions must be taken as usual to prevent oscillator pulling. No trouble is experienced with sidebands. It is also possible to determine whether any shift in frequency of the pulse modulated sine waves occurs when the pulse rate or duration of the train is altered. In the case where only a few cycles of the train are desired, the above methods do not

give sufficient accuracy for the most precise requirements.

The most accurate calibrating procedure developed to date to the author's knowledge is the method described in a previous paper[14]. This paper describes a rapid, accurate determination of spacing between pulses or sine waves having production line simplicity and laboratory precision. It is possible to ascertain whether the first cycle has the same period as the succeeding cycles. This information is important where maximum precision is desired.

Mathematical Appendix

A simplified equivalent circuit of the keyed oscillators discussed in the text is shown in Fig. 4. Switches S1 and S2 are provided to indicate various stages in the operation of the circuits.

CASE A considers the buildup characteristic of the elementary pulsed sine wave generator of Fig. 1A for which S1 and S2 are normally closed, but at $t = 0$ S2 is opened. The differential equation describing the subsequent action is

$$L\frac{di_2}{dt} + R_L i_2 + q/c = 0 \qquad (1A)$$

or

$$(DL + R_L + 1/PC)i_2 = 0 \qquad (1B)$$

Where $1/P = \int_0^t dt$

The general solution[15] of Eq. 1 is

$$i_2 = (\exp - \alpha_1 t)\,[A_1 \sin\beta t + A_2 \cos\beta t] \qquad (2)$$

In order to evaluate the arbitrary constants of integration the following boundary conditions are substituted, neglecting $I_p R_L$ drop

$t = 0, q = 0, i_2 = -I_p$, and $\left(\frac{di_2}{dt}\right) = \left(\frac{\alpha_1}{\beta_1}\right) I_p$.

The complete solution is therefore

$$i_2 = -I_p\,(\exp - \alpha_1 t)\,[\cos\beta_1 t - \alpha_1/\beta_1 \sin\beta t] \qquad (3)$$

We are primarily concerned with the potential across the capacitance

$$e_c = \frac{1}{c}\int i_2\,dt \qquad (4)$$

$$e_c = \frac{I_p}{C}\cdot\frac{\alpha_1}{\beta_1}\int(\exp - \alpha_1 t)\sin\beta_1 t\,dt - \frac{I_p}{C}\int(\exp - \alpha_1 t)\cos\beta_1 t\,dt \qquad (5)$$

Performing the indicated integration and evaluating the constant of integration gives

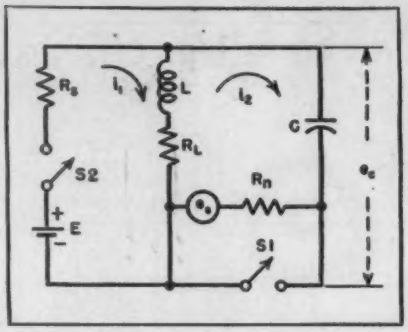


FIG. 4—Equivalent circuit of pulsed oscillator

$$e_c = \frac{-I_p}{\beta_1 C}(\exp - \alpha_1 t)\sin\beta_1 t \qquad (6)$$

If Q is very much greater than unity,

$$\beta_1 = \omega, \text{ and } \alpha_1 = \frac{\omega}{2Q}, \text{ and}$$

$$e_c = -\frac{I_p}{\omega C}(\epsilon^{-\omega t/2Q})\sin\omega t \qquad (7A)$$

or also

$$e_c = I_p\,(L/C)^{1/2}\,(\epsilon^{-\omega t/2Q})\sin(\omega t + \pi) \qquad (7B)$$

Equation 7 describes an oscillation whose decay properties depend upon the magnitude of Q. If Q is very high but R_L is still larger than zero e_c decays slowly (see Fig. 1B and 1F). If Q is infinite, that is, if $R_L = 0$

$$e_c = -I_p\,(L/C)^{1/2}\sin\omega t \qquad (8)$$

This equation expresses the case shown in Fig. 1E and 2 where the oscillator tube is adjusted to cause the effective circuit resistance to vanish. If Q is negative, that is, if R is less than zero, then oscillations build up indefinitely. Actually losses in the circuit due to nonlinearity of the oscillator tube will limit the amplitude of oscillations.

In using the circuit in Fig. 1A, assume one wishes to ascertain the Q required to sustain oscillations for n cycles so that

$$e_n = Ke_0 \qquad (9)$$

then

$$e_0 = I_p\,(L/C)^{1/2}\,(\exp - \omega t_n/2Q)\sin\omega t_0 \qquad (10A)$$

and

$$e_n = I_p\,(L/C)^{1/2}\,(\exp - \omega t/_n 2Q)\sin\omega t_n \qquad (10B)$$

but

$$\omega t_0 = \frac{\pi}{2} \text{ and } \omega t_n = 2\,(n-1)\pi + \frac{\pi}{2}$$

then

$$K = \frac{e_n}{e_0} = \exp - \frac{(n-1)\pi}{Q} \qquad (11)$$

from which

$$Q = \frac{(n-1)\pi}{l_n(1/K)} \qquad (12)$$

Figure 5 is a plot of K versus Q for several typical values of n.

The amplitude of the first cycle of oscillation may be readily obtained from the Eq. 7A. Let $\omega t = \pi/2$ and $Q>>1$ then $e_{cmax} = I_p(L/C)^{\frac{1}{2}}$. As a check this can be deduced from energy considerations where

$$\frac{1}{2}LI_p^2 = \frac{1}{2}Ce_c^2 \qquad (14)$$

and

$$e_{cmax} = I_p\,(L/C)^{1/2} \qquad (13)$$

CASE B refers to Fig. 1C for which S2 in Fig. 4 is open throughout. Before $t = 0$ S1 is closed. At $t = 0$ S1 is opened causing circuit resistance to become negative. Synchronizing pulse e_s causes transient oscillation to begin such that

$$i\,(DL + R_n + 1/PC) = e_s \qquad (15)$$

from which

$$i = \epsilon^{-\alpha t}\,[A_1 \sin\beta t + A_2 \cos\beta t] \qquad (16)$$

We are not concerned with steady state condition because e_s is negligible compared with the amplitude of the resulting oscillation. Boundary conditions are $t = 0$, $q = 0$, $di/dt = e_s/L$ giving

$$i = \frac{e_s}{\beta L}\epsilon^{-\alpha t}\sin\beta t \qquad (17)$$

and if $Q>>1$, and $R<0$ then

$$i = \frac{e_s}{\omega L}(\exp R_n t/2L)\sin\omega t \qquad (18)$$

This expression is the equation of an oscillatory current which builds up from zero to some final value determined by tube nonlinearity.

CASE C considers oscillations after application of the negative gate to the grid of the clamp tube. Oscillations will continue in a manner determined by the magnitude and sign of the effective circuit Q. When the negative gate is removed and the cathode follower is permitted to become conducting, oscillations will be damped at a rate determined by the magnitude of R_s. When S2 is closed (corresponding to removal of the negative gate), equations describing the currents in the two meshes are

$$E = i_1 (R_s + DL) - i_2 (DL) \quad (19)$$

$$0 = -i_1 (DL) + i_2 (DL + 1/PC) \quad (20)$$

(R_L is neglected as its effect is negligible compared with R_s). Equations 19 and 20 may be solved simultaneously for i_2 giving

$$i_2 \left(D^2 + \frac{D}{R_s C} + \frac{1}{LC} \right) = 0 \quad (21)$$

Roots of the auxiliary equation are

$$\left.\begin{matrix} r_1 \\ r_2 \end{matrix}\right| = \alpha_2 \pm \beta_2$$

It is not necessary for the purpose of this analysis to complete the particular solution for i_2. It is sufficient to observe that when $\beta = 0$ the circuit is critically damped and current in the capacitor can decay to zero without oscillatory overshoot; this is the borderline condition. The value of R_s required to give critical damping is deduced from

$$\beta = \left(\frac{1}{4R_s^2 C} - \frac{1}{LC} \right)^{1/2} = 0 \quad (22)$$

For the overdamped condition

$$R_s < \frac{1}{2} (L/C)^{1/2} \quad (23)$$

It should be noted that in circuits shown in Fig. 1E and 2 there are two transients. There is the transient resulting from current I_s which flows when S2 is closed, and the residual alternating current which remains when S1 is closed. By the principle of superposition each condition may be considered separately. Both conditions give similar differential equations but have different boundary conditions, which do not affect the analysis because we are not concerned with currents but rather with rates of decay of currents. It is evident that for rapid damping at high oscillator frequencies a cathode follower having low cathode to ground resistance is essential. Otherwise decay time may be considerably longer than rise time of the pulse modulated oscillator waveform envelope.

If R_s can be made very small so that $(1/4R_s^2C^2) >> (1/LC)$ then $i_2 = A_1 (\exp -t/R_sC)$ and i_2 will decay exponentially to a value of $1/e$ in R_sC seconds.

Substitution of typical values into the last equation gives the following data: either $f = 1$ mc, $C = 100 \mu\mu f$, $L = 250$ μh, $R = 790$ ohms, and $t = R_sC$ 7.9×10^{-6} sec, or $f = 10$ mc, $C = 25$ $\mu\mu f$, $L = 10$ μh, $R = 316$ ohms, in which case $t = 7.9 \times 10^{-6}$ sec.

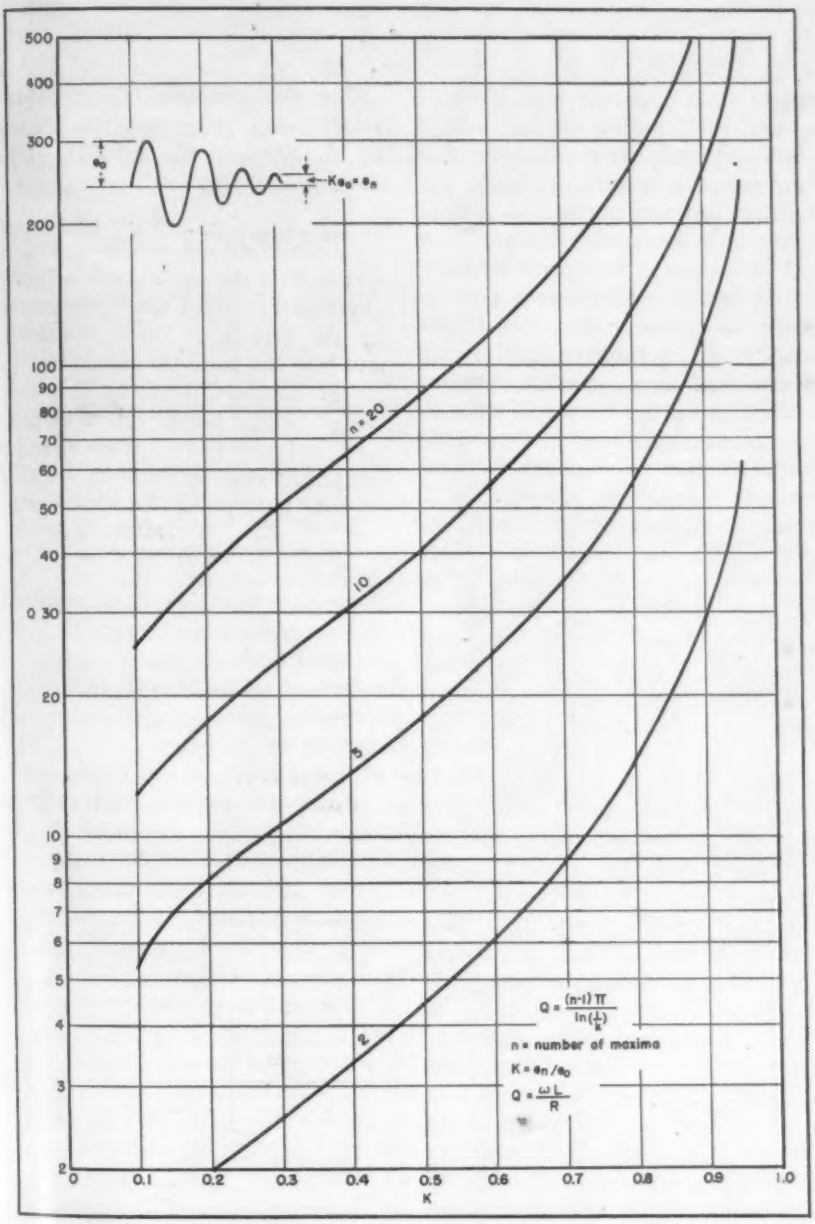


FIG. 5—Graph shows the quality (Q) of a resonant circuit if the oscillations initiated by shock are to decay to a particular fraction (K) of their initial value in a given number (n) of cycles

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By means of a compound feedback circuit extreme stability is obtained in a conductively coupled electronic instrument. Positive feedback produces an effectively infinite gain that is highly degenerated by negative feedback

cathode resistor. The circuit may thus be considered as a "plate follower" in distinction to the cathode follower type of circuit.

Realizing the Conditions

The absence of cathode resistance permits the introduction of additional tube elements without involving their operation with the degenerative function of the control grid. In the two-tube circuit of Fig. 2 this feature of independence allows the introduction of a second grid to obtain regeneration, resulting in an effective increase in *M*. The second grid of each tube is crossed to the plate of the opposite tube to obtain regeneration in a manner similar to the action of a multivibrator. An adjustable plate-to-plate shunting resistor allows adjustment of the degree of regeneration. In practice the second grid is most conveniently the screen grid of a standard pentode, which is designed to operate at voltages comparable to the plate voltage without secondary emission complications.

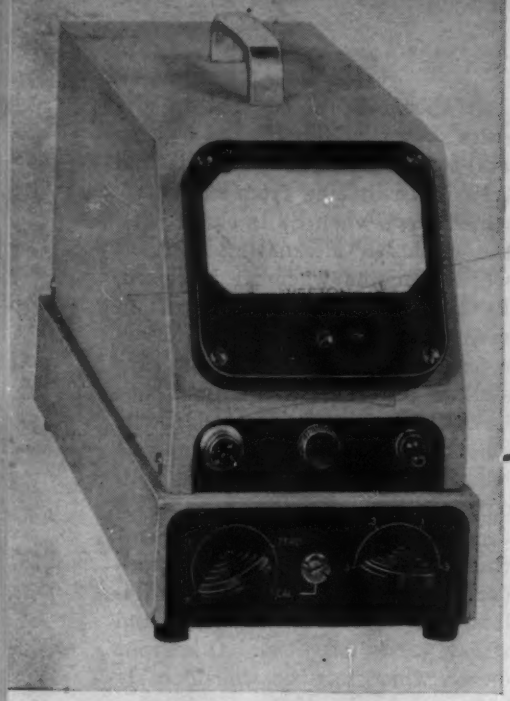
If the control grids are temporarily made ineffective, for example by disconnecting and biasing from a separate source, and the regeneration control increased, a point of instability will be reached where the circuit will fall over, one tube blocking and the other conducting in the manner of a half cycle of multivibrator operation. At this point the circuit is critically regenerated and is essentially an amplifier of infinite gain. If the control grids are then reconnected to the degenerative coupling batteries all tendency toward instability will be restrained by superimposed degeneration and the circuit will function as the circuit of Fig. 1 containing a tube of infinite *M*. In fact the regeneration control may be further advanced and the circuit operated in the seemingly impossible region of greater than infinite (negative) internal gain.

With the circuit adjusted to this point of critical regeneration, the control grids exert only a transient type of control upon the tube space paths, while the regenerated screen grids and plates do the actual work of establishing the output voltage. If the control grid-cathode voltages are observed while an input voltage is applied, no change is noticeable, and this condition of zero grid excursion may be used in practice as the criteria for adjustment of the regeneration control. If the regeneration control be adjusted above or below the critical point while the circuit is subjected to an input variation, a control grid excursion will appear but of a polarity with respect to the input dependent upon the direction of misadjustment.

Chassis contains power supply and amplifier circuit of voltmeter; indicating instrument is mounted on cover

In a practical instrument amplifier the feature of zero grid excursion for a tangible plate voltage output means a materially more linear relationship between input and output because the plate and screen grid variational factors are more constant over wider voltage excursions than the control grid. Also the tubes can be operated at

STABLE VOLTMETER



Experimental model of electronic direct-coupled voltmeter

By R. W. GILBERT

Electronic Engineering Division
Weston Electrical Instrument Corp.,
Newark, N. J.

VACUUM TUBE amplification to extend the sensitivity of direct indicating electrical instruments has attracted the attention of numerous investigators, resulting in many effective methods for obtaining stability beyond that normally required for sound amplification. The impedance coupled alternating-current instrument amplifier has been particularly highly developed, largely by properly applied degeneration effective over the frequency range desired. The conductively coupled amplifier, responsive to both alternating and direct current, has however proved more difficult because of circuit limitations imposed by the necessity for both amplifying and degenerating through the conductively coupled circuit loop.

Condition for Stability

Broadly the attainment of stability in the face of variable tube coefficients is a problem of sacrificing a maximum of inherent amplification by degeneration, resulting in less gain but a proportionately greater stability. From this viewpoint it is apparent that the optimum combination is an infinite inherent gain which is completely degenerated, resulting in an amplifier having a nominal overall gain and first order independence of variations in tube coefficients.

At first it would appear possible only to approach but not obtain this condition because infinite gain considered as a separate function would be on the threshold of self-sustained oscillation. However, the superposition of degeneration exerts a stabilizing influence, and, unless inhibited by the time constants of the circuit, a stable overall system is possible. The present circuit is capable of adjustment to and beyond this ideal condition, and in practice reduces the influence of tube variables entirely to a second order effect.

Consider the circuit of Fig. 1 wherein the plate of the triode is conductively coupled to the grid through a battery equal to the voltage normally existing between these elements in a conventional amplifier circuit. Coupling of this nature is essentially degenerative in direction inasmuch as any plate voltage variation is transmitted to the grid as a corrective control to partially restore the original plate voltage. If an input voltage e is injected in series with the grid the voltage change E' appearing at the plate is in a direction to reestablish the original grid voltage through the coupling battery. Thus the plate voltage shift is a measure of the input voltage, but less by an amount that is a function of the amplification factor.

For this condition the feedback relationship (Regeneration Theory by H. Nyquist, *B.S.T.J.*, 11, 1932, Jan., p 126) applies

$$\text{Overall voltage ratio} = \frac{E}{e} = \frac{M}{Mb + 1} \qquad (1)$$

where M is the amplification factor (voltage ratio) of the tube proper in its circuit without feedback, and b is the transfer characteristic of the feedback loop, in this case the plate-grid degenerative connection. But here plate voltage changes are transmitted entirely to the grid so b is unity, and Eq. 1 becomes

$$\frac{E}{e} = \frac{M}{M + 1} \qquad (2)$$

From this equation it is apparent that as M becomes larger the overall amplification factor approaches unity and, which is more important, becomes more independent of changes in M.

This circuit is similar in function to the conventional cathode follower circuit except that the resistance mutual to the input and output circuits is in the form of a plate resistor rather than a

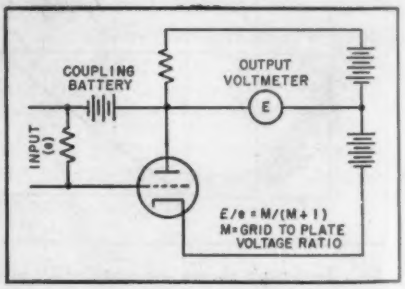


FIG. 1—Degenerative coupling from plate to grid, through a battery to preserve the required operating potentials on grid and plate, stabilizes the tube circuit

series, at normal operating current. Capacitive bypassing has limitations because, if sufficiently heavy, the tubes may be damaged when starting. Also resonance against the internal equivalent inductance can actually increase the loading at the resonant frequency. However, as an instrument amplifier application is limited largely to d-c and a-c not exceeding audio frequency, where this inductive loading effect is not serious.

For simplicity of explanation it is assumed that the circuit of Fig. 3 is arranged to provide a voltage ratio of unity, whereas any voltage ratio is possible by incorporating a degenerating network rather than a simple mutual resistance. Also four basic operating combinations are possible; voltage input with voltage output, voltage input with current output, current input with voltage output, and current input with current output. These combinations are shown in Fig. 4 as changes to the circuit of Fig. 3, together with the expressions for the gain in each case. Note that for current input a current balance network is employed rather than adapting the voltage input circuit to current by passing the input current through an input shunt. This current balance arrangement balances the input terminals to zero potential, maintaining effectively zero resistance looking into the input end of the amplifier. Thus in the case of current as well as voltage inputs the circuit demands no energy from the input source.

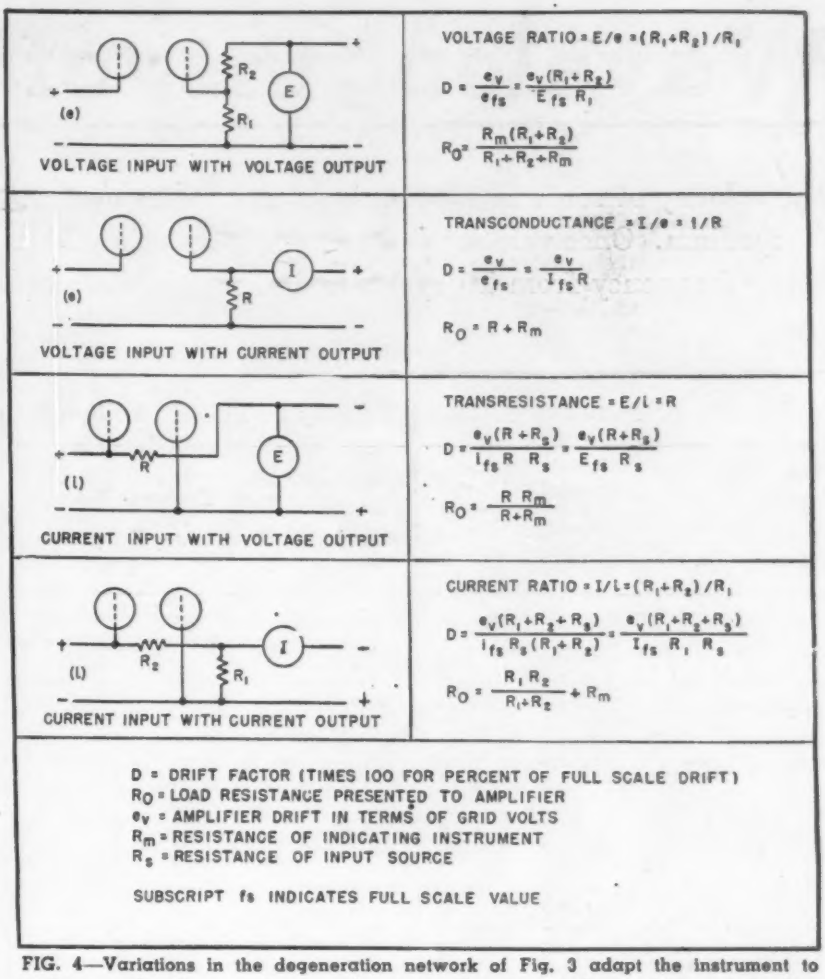

VOLTAGE INPUT WITH VOLTAGE OUTPUT
VOLTAGE RATIO = E/e = (R1+R2)/R1
D = ev/efs = ev(R1+R2)/Efs R1
RO = Rm(R1+R2)/(R1+R2+Rm)
VOLTAGE INPUT WITH CURRENT OUTPUT
TRANSCONDUCTANCE = I/e = 1/R
D = ev/efs = ev/Ifs R
RO = R + Rm
CURRENT INPUT WITH VOLTAGE OUTPUT
TRANSRESISTANCE = E/I = R
D = ev(R+Rs)/Ifs R Rs = ev(R+Rs)/Efs Rs
RO = R Rm/(R+Rm)
CURRENT INPUT WITH CURRENT OUTPUT
CURRENT RATIO = I/I = (R1+R2)/R1
D = ev(R1+R2+Rs)/Ifs Rs(R1+R2) = ev(R1+R2+Rs)/Ifs R1 Rs
RO = R1 R2/(R1+R2) + Rm
D = DRIFT FACTOR (TIMES 100 FOR PERCENT OF FULL SCALE DRIFT)
RO = LOAD RESISTANCE PRESENTED TO AMPLIFIER
ev = AMPLIFIER DRIFT IN TERMS OF GRID VOLTS
Rm = RESISTANCE OF INDICATING INSTRUMENT
Rs = RESISTANCE OF INPUT SOURCE
SUBSCRIPT fs INDICATES FULL SCALE VALUE

FIG. 4—Variations in the degeneration network of Fig. 3 adapt the instrument to various combinations of input and output. Equations indicate drift and loading

Drift

In common with all conductively coupled amplifiers the circuit is inherently a high input impedance device and is at a disadvantage from the standpoint of zero stability when operated from low impedance, low voltage sources such as a thermocouple. The tendency to zero drift is caused principally by contact potential variations within the input tubes, but all circuit components contribute more or less to the total drift. However, for simplicity the amount of drift that can be expected from the tube circuit proper is best expressed as the equivalent grid potential variation, or the amount of grid potential change required to rebalance the circuit after drift has taken place. The effect of this potential change in terms of output can then be calculated from the constants of the degenerating network, and expressed as a drift factor D for any set of conditions. The expression for the drift factor is given in Fig. 4 for the four basic degenerating networks in terms of the equivalent grid potential drift variations e_v. Note that in the case of current input the resistance of the input current source is effectively in parallel with the grid circuit and enters the expression. The drift factor expresses the ratio of expected drift to full scale output or input, and can be multiplied by 100 to obtain the expected drift in percent. Note also that the load presented to the amplifier output R_o does not enter the drift expression because an optimum adjustment of regeneration is assumed; in case of misadjustment the load resistance will have a small second order effect upon drift.

In practice e_v can be determined experimentally by setting up the unity gain circuit of Fig. 3 with the input terminals short circuited. As the circuit drifts, e_v is read directly on the output voltmeter.

An experimental design of electronic d-c voltmeter using the compound feedback circuit was built. This particular instrument includes features of convenience such as input polarity reversal and center zero switch positions, and means for calibration and zero adjustment without disconnecting the input. It contains an input network for four voltage ranges from 100 millivolts to three volts. An experimental companion instrument for current measurements down to 0.1 microampere full scale, similar in appearance to the electronic voltmeter, was also designed.

the quiescent grid current point throughout the range of input, minimizing grid current demand in sensitive direct-current applications.

Significance of Circuit Characteristics

When critically regenerated, the circuit also has the interesting property of behaving as an output voltage source of zero variational resistance within functional limits. In operation with an input voltage applied, the output voltmeter may be shunted to demand more output current without affecting its reading. Conversely series resistance may be added to the coupling battery circuits without affecting the output reading. In either case the plate to screen-grid regenerative action supplies the additional output energy without requiring any static change in the control grid potentials, so the overall voltage ratio remains constant. Insufficient regeneration causes a positive variational resistance to appear, and excessive regeneration causes a negative variational resistance. In the latter case shunting the output voltmeter will increase its reading. Naturally if regeneration is increased beyond the critical point to where the negative resistance looking into the output end of the amplifier is greater than the positive resistance within the output voltmeter, the circuit will become unstable and fall over. Also as regeneration is increased from the optimum critical point to the point of instability the overall voltage ratio varies to infinity. These effects have no probable practical significance but serve to demonstrate the fact that considerable latitude exists between the point of optimum adjustment and the region of instability. In fact unless the resistance of the output voltmeter is quite low, complete removal of the regeneration control resistor will not produce instability in standard pentode type tubes.

When used as a d-c amplifier the question of zero stability becomes of interest. No material advantage over conventional d-c amplifier circuits is apparent in respect to stability, but in general the usual precautions apply. Use of two tubes in opposition reduces the effect of contact potential variations to a differential rather than a direct effect, so that regulation of the heater supply voltage, if necessary, is really effective. The major cause of zero drift then becomes the differentials between the two tubes that change with time, which fundamentally cannot be compensated and can only be reduced by the use of matched tubes.

Practical Circuit

The circuit of Fig. 3 is essentially the circuit of Fig. 2 reduced to a practical arrangement. The coupling batteries are replaced by cold-cathode gas voltage regulator tubes which have sufficiently low internal variational resistance not to load the output circuit unduly. The input tubes are followed by a stage of cathode followers primarily to remove the output load and the regulator tube current from the regenerative portion of the circuit. Without the buffer action of the cathode followers it might prove impossible to supply the desired output without loading the input tubes to the point where critical regeneration is not attainable. While a battery plate supply is shown for simplicity, the circuit is particularly adaptable to service power supply with a minimum of filtering because the regulator tubes effectively regulate the element voltages. This regulation together with the zero resistance output characteristic removes virtually all supply voltage ripple from the output.

The gas regulator tubes unfortunately have a small equivalent internal inductance due to the total ion mass in the space path. In an alternating-current amplifier this inductance causes an additional output loading factor that manifests itself increasingly with increasing frequency. This inductance is in the order of six millihenrys in small tubes (Type 991, etc.) and 80 mh in larger tubes such as the VR

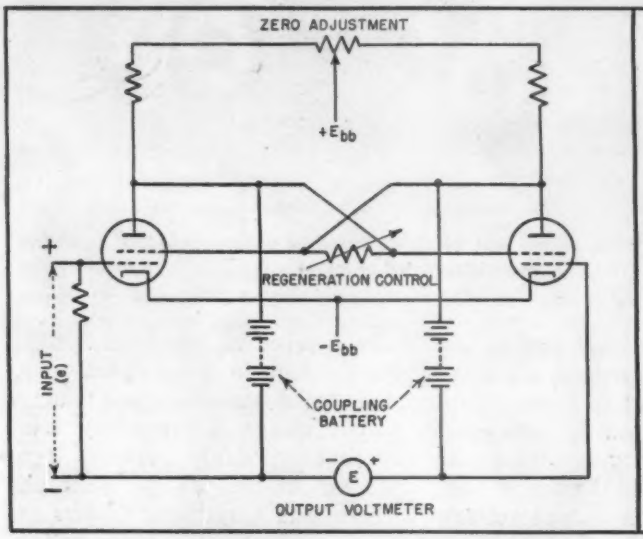


FIG. 2—Regenerative feedback to auxiliary grids increases amplification. Balanced circuit is used to obtain necessary phase reversals

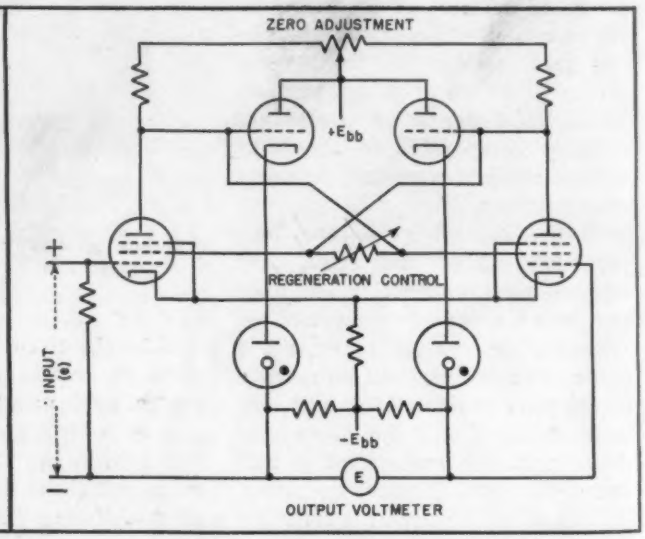


FIG. 3—Practical circuit incorporates cathode-coupled isolation tubes and gas tubes in place of batteries for maintaining proper biases

Wavelengths of SOUND

The velocity of sonic or ultrasonic energy varies over a range of 50 to 1, depending on the medium. Once velocity is determined, by using the table below, the wavelength for any frequency from 10 cycles to 100 megacycles can be found on the nomograph

By BERTHA W. HENVIS

Crystal Section
Office of Research and Inventions
Naval Research Laboratory
Washington, D. C.

Velocity of Sound in Solids

Material	Longitudinal Bar Velocity in cm per sec	Plate (Bulk) Velocity in cm per sec
Aluminum	5.24×10^5	6.4×10^5
Antimony	3.40×10^5	.....
Bismuth	1.79×10^5	2.18×10^5
Brass	3.42×10^5	4.25×10^5
Cadmium	2.40×10^5	2.78×10^5
Constantan	4.30×10^5	5.24×10^5
Copper	3.58×10^5	4.6×10^5
German Silver	3.58×10^5	4.76×10^5
Gold	2.03×10^5	3.24×10^5
Iridium	4.79×10^5	.....
Iron	5.17×10^5	5.85×10^5
Lead	1.25×10^5	2.4×10^5
Magnesium	4.9×10^5	.....
Manganese	3.83×10^5	4.66×10^5
Nickel	4.76×10^5	5.6×10^5
Platinum	2.80×10^5	3.96×10^5
Silver	2.64×10^5	3.60×10^5
Steel	5.05×10^5	6.1×10^5
Tantalum	3.35×10^5	.....
Tin	2.73×10^5	3.32×10^5
Tungsten	4.31×10^5	5.46×10^5
Zinc	3.81×10^5	4.17×10^5
Cork	0.50×10^5	.....
Crystals, quartz, X-cut	5.44×10^5	5.72×10^5
ADP ($NH_4H_2PO_4$) 45° Z-cut	3.28×10^5	4.92×10^5
Rochelle Salt, 45° Y-cut	2.47×10^5	.....
Rochelle Salt, 45° X-cut	See Fig. 2	
Rochelle Salt, L-cut	.....	5.36×10^5
Tourmaline, Z-cut	.....	7.54×10^5
CaF_2 (fluorite), X-cut	6.74×10^5	7.18×10^5
NaCl (Rock salt), X-cut	4.51×10^5	4.78×10^5
NaBr, X-cut	2.79×10^5	3.2×10^5
KCl (sylvite), X-cut	4.14×10^5	4.38×10^5
KBr, X-cut	3.38×10^5	3.48×10^5
Glass, heavy flint	3.49×10^5	3.76×10^5
extra light flint	4.55×10^5	4.80×10^5
heaviest crown	4.71×10^5	5.26×10^5
crown	5.30×10^5	5.66×10^5
quartz	5.37×10^5	5.57×10^5
Granite	3.95×10^5	.....
Ivory	3.01×10^5	.....
Marble	3.81×10^5	.....
Slate	4.51×10^5	.....
Wood, elm	1.01×10^5	.....
oak	4.1×10^5	.....

Velocity of Sound in Liquids

Material	Temperature in deg C	Velocity in cm per sec
Alcohol, ethyl	12.5	1.24×10^5
	20	1.17×10^5
Benzene	20	1.32×10^5
Carbon bisulfide	20	1.16×10^5
Chloroform	20	1.00×10^5
Ether, ethyl	20	1.01×10^5
Glycerine	20	1.92×10^5
Mercury	20	1.45×10^5
Pentane	18	1.05×10^5
	20	1.02×10^5
Petroleum	15	1.33×10^5
Turpentine	3.5	1.37×10^5
	27	1.28×10^5
Water, fresh	17	1.43×10^5
Water, sea	17	1.51×10^5

Velocity of Sound in Gases

Material	Temperature in deg C	Velocity in cm per sec
Air	0	0.331×10^5
	20	0.343×10^5
Argon	0	0.319×10^5
	300	0.307×10^5
Ammonia gas	0	0.415×10^5
Carbon dioxide	0	0.259×10^5
Carbon monoxide	0	0.338×10^5
Chlorine	0	0.206×10^5
Deuterium (heavy hydrogen)	0	0.890×10^5
Ethane	10	0.308×10^5
Ethylene	0	0.317×10^5
Hydrogen	0	1.28×10^5
Hydrogen bromide	0	0.200×10^5
Hydrogen chloride gas	0	0.296×10^5
Hydrogen iodide	0	0.157×10^5
Hydrogen sulfide	0	0.289×10^5
Helium	0	0.97×10^5
Methane	0	0.430×10^5
Neon	0	0.435×10^5
Nitric oxide	10	0.324×10^5
Nitrogen	0	0.334×10^5
	20	0.351×10^5
Nitrous oxide	0	0.26×10^5
Oxygen	0	0.316×10^5
	20	0.328×10^5
Sulphur dioxide	0	0.213×10^5
Water vapor	0	0.401×10^5
	100	0.405×10^5

THE TABLES give the longitudinal bar and bulk velocities of sound in various solids, as well as the velocity of sound in some liquids and gases.

The effective velocity of sound, V, to be used in these calculations is a rather complex function of the exciting frequency and the shape and dimensions of the vibrating element. Very few three-dimensional elastic solid problems have been studied in detail, but the following comments may be used as a guide in obtaining an approximate value of the effective velocity in the elements of many vibrating systems.

For cylindrical elements of ap-

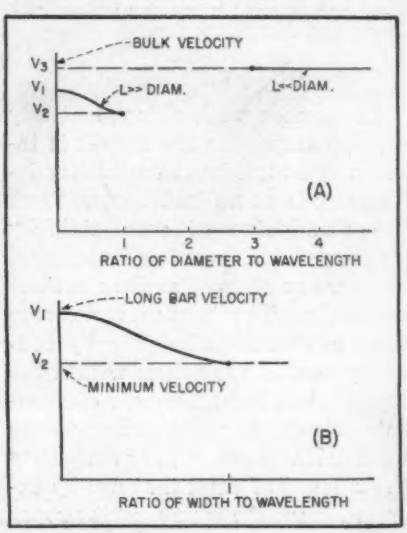


FIG. 1—Variation of velocity of sound with dimensional ratios of solids

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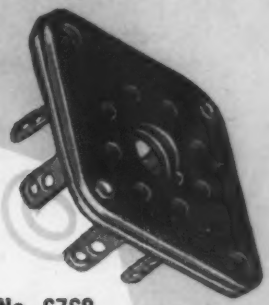

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proximately circular or square cross-section, with free sides, the effective velocity varies with the ratio of diameter to wavelength as illustrated by Fig. 1A, where V_2 is the bulk velocity and V_1 is the long bar velocity. For most metal backing materials the ratio V_2/V_1 is about 0.65.

For rectangular elements with free sides whose thickness is less than the width, the effective velocity for the element vibrating in extension (not thickness) varies with the ratio of width to wavelength as illustrated by Fig. 1B. Crystals are usually of such size that this curve is applicable. The ratio V_2/V_1 can be taken as equal to 0.8 for most of the cuts of crystals in general use.

Constraints on the sides of the cylindrical elements have the effect of increasing the ratio of diameter to wavelength. Similarly, constraining the sides of rectangular elements increases the effective ratio of width to wavelength.

The velocity for a zero diameter-to-wavelength ratio is the long bar velocity, and the velocity for an infinite diameter-to-wave-length ratio is the bulk (plate) velocity.

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(4) Fry, William J., Taylor, John M., and Henvis, Bertha W., "Design of Crystal Vibrating Systems for Projectors and Other Applications," Naval Research Laboratory, August 1945. Much of the data herein presented is based on material in this report.

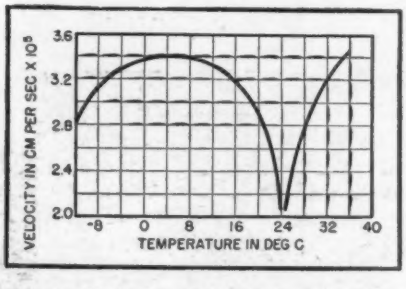

FIG. 2—Variation of longitudinal velocity in 45-degree X-cut Rochelle-salt crystal with temperature

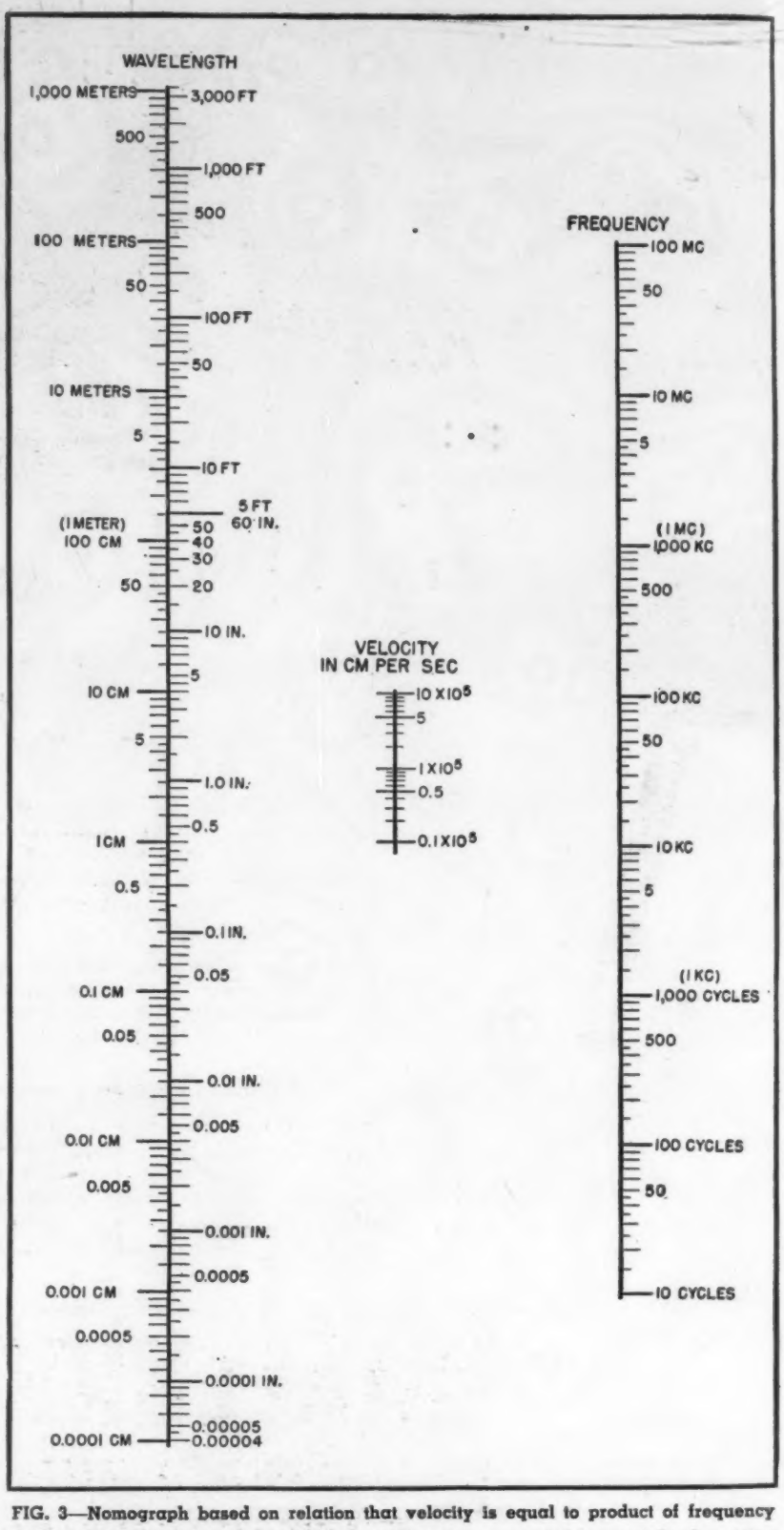

FIG. 3—Nomograph based on relation that velocity is equal to product of frequency and wavelength. When any two known values are connected by straightedge, intersection with third scale determines value sought

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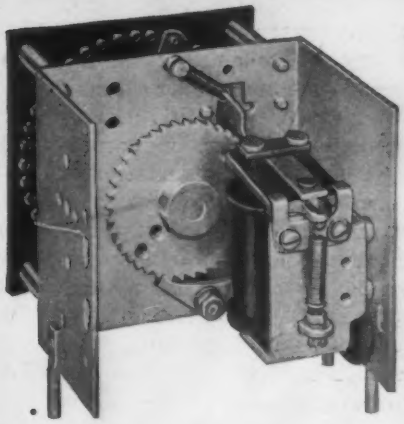

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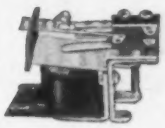

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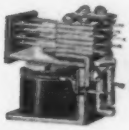

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TUBES AT WORK

Edited by VIN ZELUFF

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Soldering Litz Ends..... 158
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Metallized Capacitor Data..... 174

Microwave Communications System

THE RAYTHEON microwave communications system (ELECTRONICS, Oct. 1946, p 146) is composed of point-to-point radio relay equipment operating in the 2,450-2,700-mc or 3,700-4,200-mc region.

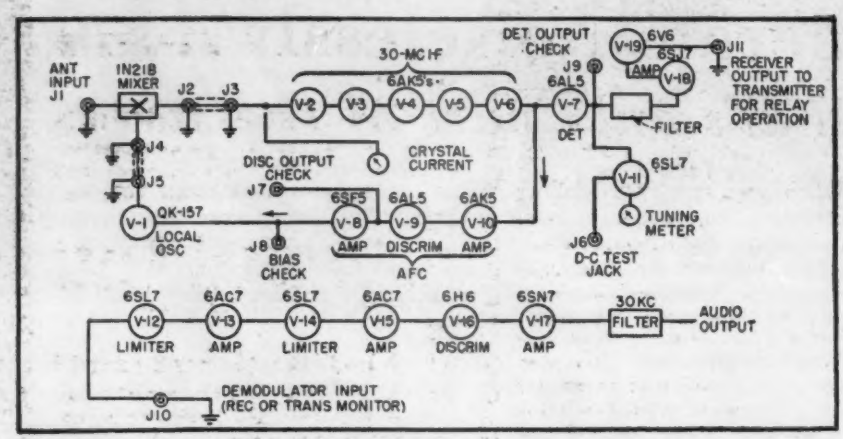
An intelligence band from 30 cycles to 30 kc is transmitted. This band can be channelized in any desired manner for the simultaneous transmission of telephone, telegraph, teleprinter, and other types of information.

The transmission system utilizes the Fraim method of modulation, in which the aggregate intelligence frequency-modulates a 240-kc subcarrier. The peak frequency swing extends from 180 to 300 kc. The subcarrier excitation, which has a square waveform, operates a keyer tube which alternately interrupts a magnetron anode supply at the subcarrier rate. The radiated wave therefore consists of 4,000-mc oscillations which are keyed on and off at a rate which varies between 180 and 300 kc.

The front end of the receiver employs a conventional superheterodyne arrangement in which the incoming signal from the antenna is mixed with a local oscillator to provide 30-mc i-f excitation. The i-f amplifier is followed by a conventional a-m detector. At this point the received signal is simply a frequency-modulated square wave. The output of the detector is transmitted through a bandpass filter to eliminate extraneous noise. The f-m square wave is then limited and frequency-detected in a low-distortion discriminator circuit.

As in all f-m systems, two signal level requirements must be met for satisfactory operation: the carrier-to-noise level in the bandpass filter before the subcarrier limiters must exceed six db under all conditions of circuit fading, and adequate signal-to-noise level must be provided in the intelligence channel for the particular type of information transmitted.

Tests demonstrate that the transmitted power is sufficient to allow for 40 db of fading before the signal drops below the noise threshold. This eliminates the necessity for diversity reception in the majority of installations.

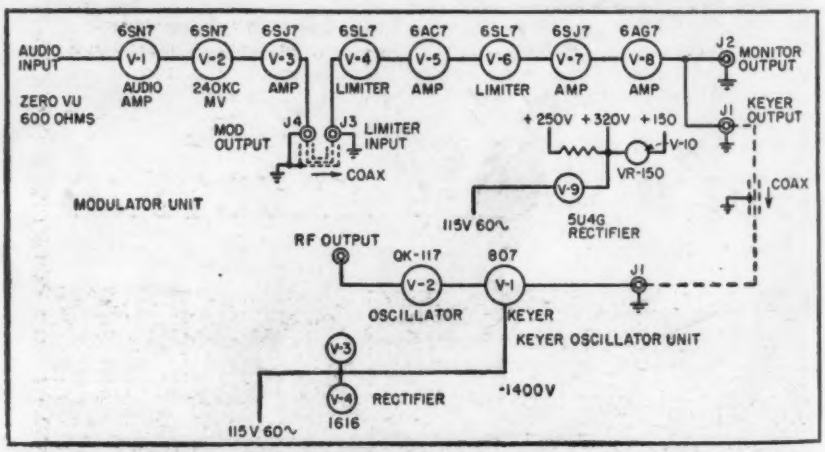


Block diagram of the microwave receiver. A klystron oscillator feeds a crystal mixer for conversion

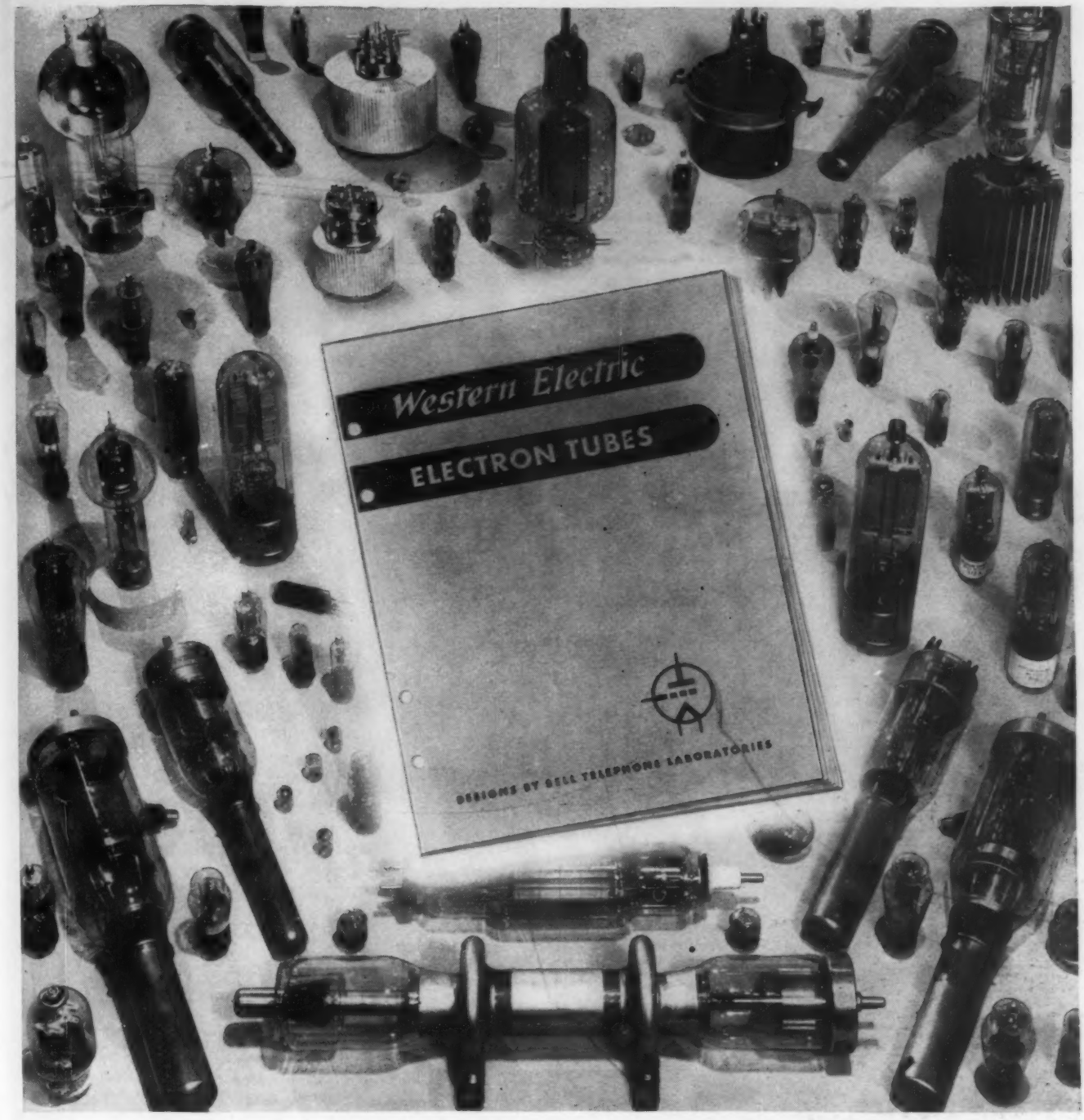
Antenna System

For economical as well as technical considerations, Raytheon recommends that two-way repeater station antennas be mounted on two poles joined by a wooden crossarm and adequately guyed. One transmitting and one receiving antenna are mounted on each pole, as nearly back-to-back as possible. Transmitting antennas should have like polarization and be diametrically spaced. Receiving antennas should have like polarization but differing by 90 degrees from that of the transmitting antennas. All r-f equipment, except the transmission line and antenna, is on the ground.

Three basic types of antennas are used: a two-foot solid parabolic dish with dipole feed, a 3 x 3-foot screen section of a parabolic dish with horn-type feed, and a 46-inch circular section of a parabolic dish with cavity dipole feed. The approximate gains are respectively 25, 28 and 32 db. The appropriate antenna



Block diagram of the microwave transmitter. Jacks permit operation as repeater or terminal equipment and allow monitoring of circuits



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In concise, tabular form, this new book gives the essential data on 166 codes of electron tubes designed by Bell Laboratories and made by Western Electric. Planned to help the circuit designer quickly find the tube best suited to his needs, it contains technical characteristics, ratings, dimensions and 89 basing diagrams—all arranged for quick, easy reference. Send the coupon for your copy today!

E-3

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— QUALITY COUNTS —

should be chosen for the path circuit conditions, such as distance of transmission and type of intervening terrain. Waveguide feeds have been found more practical than dipole assemblies because of the more stable operation under all weather conditions and the ease of initial adjustment.

Transmitter

The circuit of a 50-watt microwave transmitter is shown in the accompanying diagram. Tube V-2 is a multivibrator whose frequency is directly controllable by varying its bias. In an unmodulated condition the frequency of this subcarrier oscillator is 240 kc. Under modulating conditions, the variation of the audio signal causes the relaxation oscillator to shift in frequency from a minimum value of approximately 180 kc to a maximum value of approximately 300 kc. Tube V-3 is a conventional buffer amplifier.

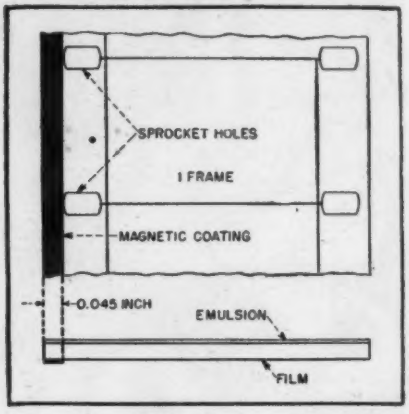
The portion of the circuit so far described represents a complete f-m system, utilizing a 240-kc carrier. This carrier could be transmitted over an open-wire line, a coaxial cable, or, as in this instance, over an additional microwave carrier. Since any concomitant amplitude modulation is undesirable in an f-m system and may add noise in the transmitting end unless removed by limiting, tubes V-4, V-5, V-6, V-7, and V-8 are provided to accomplish this function by allowing the signal to swing their grids from cutoff to plate saturation. The 807 tube performs the switching function; it keys the oscillator QK-117 (4J65) on and off at the subcarrier rate by interrupting the anode supply voltage from the 1616 rectifiers.

In the receiver portion of the system, the incoming signal from the antenna is combined with output from a QK-157 klystron oscillator in a crystal mixer to provide the 30-mc signal. Tubes V-2, V-3, V-4, V-5, and V-6 amplify this i-f signal before a-m detection in tube V-7. Tubes V-8, V-9, and V-10 functionally combine to frequency-control the local oscillator automatically. The detected signal from tube V-7 is transmitted through an 80-400-kc bandpass filter. Tubes V-12, V-13, V-14, and V-15 amplitude-limit the subcarrier before it is converted into amplitude modulation by the f-m to a-m discriminator tube V-16. Tube V-17 is an ordinary audio amplifier which is followed by a 30-kc low-pass filter.

Magnetic Sound for Amateur Movies

A SIMPLE system for putting a sound track on movie film either in manufacture or after the reel has been exposed and developed has been announced by Armour Research Foundation. This has been made possible by development of a magnetic material for coating the film that has a high coercive force.

The new material has a fine grain size of a micron or less. It is not affected by photographic solutions, so that magnetic sound can be recorded simultaneously with the picture, or can be put on afterwards. The magnetic track is put on the film by coating a track 0.045 inch wide and 0.0005 inch thick on the edge of ordinary sixteen-millimeter film. This runs through the projector at the standard sound speed of 36 feet per minute.



The magnetic coating can be applied to one edge of 16-mm film and the opposite edge left blank, coated with nonmagnetic material, or used as a second sound track for more intimate remarks to a select group

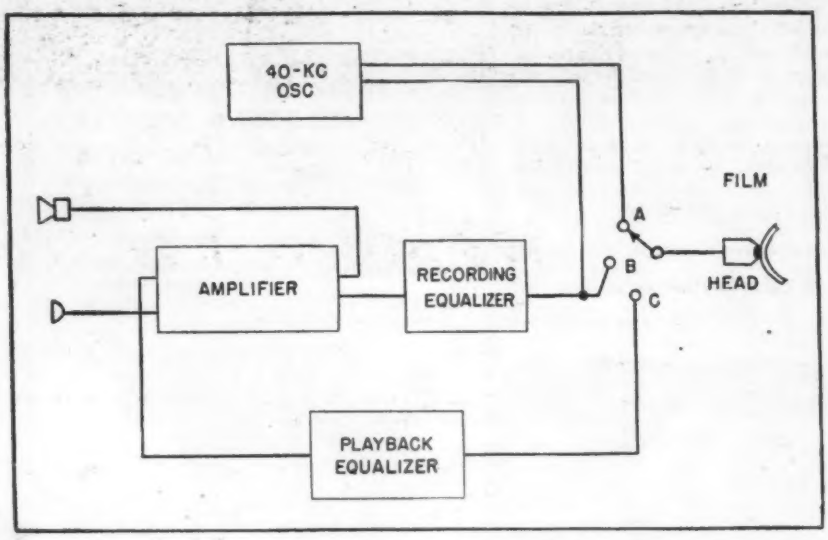
Although the coating makes the film thicker on one edge than the other, no difficulty has been experienced in reeling. To insure symmetry, the opposite edge could be coated with an equal thickness of blank material, or an additional track could be put on that edge. The extra track could be used for a binaural system or for special sound effects.

Instead of placing a track on the outside of the film, 16-mm sound film can be used with the track on the unsprocketed side to allow a wider track and increased fidelity.

The magnetic head used to play back the sound is spring-pressed against the film while it rides on a flywheel stabilizer. Such a head is easily mounted on conventional projectors and can be connected to an a-f amplifier. By switching circuits the same head can be used for erasing, recording, or playback.

As shown in the block diagram

(continued on p 158)



Essential stages of the magnetic sound system for home movie film

When a little means a lot

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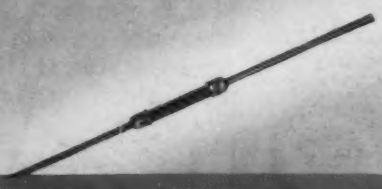

MPM Resistors

¼ watt for UHF. Resistance film permanently bonded to solid ceramic rod. Length only 9/16". Diameter 1/16". Available resistance values 30 ohms to 1.0 megohms.

TYPE H Fingertip Control

Composition volume or tone control. Its 13/16" diameter and ½" overall depth include knob and bushing.

ILLUSTRATIONS ACTUAL SIZE

I = E/IRC

BTR Resistors

⅛ watt—insulated composition. Length only 13/32". Diameter 3/32". Resistance range 470 ohms to 22 megohms (higher on special orders).

TYPE SH Fingertip Switch

Similar to TYPE H Control (left) in appearance. 13/32" diameter. OFF and 3 operating positions.

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INDUSTRIAL CONTROL

Edited by VIN ZELUFF

Telemetering In Stratosphere 142
Electrostatic Flocking 142
Fluorescent Lamp Delay Timer 184
First Factory F-M Radiophone 188
Ultrasonics, A New Tool 190

Telemetering In Stratosphere

TESTS of V-2 rockets fired at the U. S. Army Ordnance Proving Ground, White Sands, N. M., now supply 28 items of information to the ground observers every 1/35th of a second. This job is done by 10 electronic tubes in the rocket warhead, powered by a 28-v battery.

The General Electric system is mechanically commutated. Each of a number of quantities of interest is converted to a voltage between zero and plus five volts and then is connected to one segment of a stationary commutator. Twenty-eight such channels are provided and a rotating brush samples each of these 35 times per second. The voltages are converted to pulse-width-modulation of a five-watt transmitter.

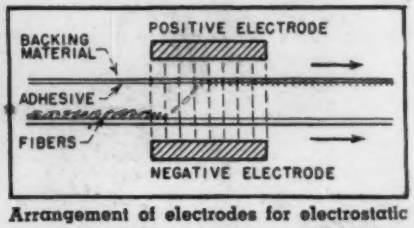
At the receiving station, each incoming signal forms a line on a c-r tube whose length is proportional to the quantity being measured.

Gyro steering control and telemetering of 28 instruments in flight is done with G-E equipment in tests of the V-2 rockets. The gantry crane shown above has expedited preparation and assembly of the electronic control gear in the missile

Electrostatic Flocking

ELECTROSTATIC coating or flocking of fibers to form a pile fabric is a new industrial technique using high potentials like those encountered in painting, detearing, and depositing of sand particles for sandpaper.

In the electrostatic method of making pile fabrics, the backing material is coated with an adhesive and fed between a pair of electrodes so that the adhesive faces downward. Evenly cut fibers of wool, cotton, rayon, and the like are fed continuously on a moving belt that travels parallel to the backing material. When the fibers are caught in the electric field they are whisked up to the adhesive coating and embedded. Because the fibers all have the same polarity, they repel one another uniformly and space themselves out at equal distances apart. The potential required from the high-voltage power supply varies from 50,000 to 100,000 volts.



Arrangement of electrodes for electrostatic deposition of fibers to form a pile fabric

To obtain good flocking of high density and uniform appearance, the textile fibers must be cut to uniform lengths. This is more economical than subsequently shearing nonuniform flocked fibers to obtain a level pile surface. Fiber cutting machines have been developed that give highly uniform cut lengths, and as a consequence electrostatically flocked materials require no shearing or singeing operations.

The first commercial use of electrostatic flocking of textiles was in the decoration of dress goods, by

(continued on p 184)

THE ELECTRON ART

Edited by FRANK ROCKETT

Proton Microscope 144
Noise in Gas Tubes..... 144
Negative Impedance 198
Shielding Filters for Insertion Loss Measurement..... 198
Noise Suppression Circuit..... 202
Experimental UHF Equipment..... 204
Self Balancing Phase Inverter..... 212

Proton Microscope

A PROPOSED electrostatic microscope would make use of protons instead of electrons, because neither mass nor charge of the beam corpuscles enter the equation for image formation. For the same accelerating potential, the limit of useful magnification for the proton microscope is forty times that of the electron microscope, because of the smaller diffraction pattern of the former. Penetrating power of protons is less than electrons, so such a microscope would be limited to use with extremely thin samples or for reflecting targets. Details separated by 3A should be resolvable. A direct magnification of 20,000 could be expected, which could be increased to 600,000 by photographic enlargement (*Comp. Rend.*, p 770 May 1945).

Noise in Gas Tubes

BY J. D. COBINE AND C. J. GALLAGHER

Radio Research Laboratory
Harvard University
Cambridge, Mass.
(Authors now at Research Laboratory, General Electric Co., Schenectady, N. Y.)

NOISE FOR visual presentation of filter frequency response and for reverberation can be obtained from gas tubes. High level, wideband noise sources, developed during the war for use in radar jammers, provide greater output than previously obtained.

Characteristics of Gas Tubes

Gas tubes have always had a reputation of being noisy, although the character of the noise has not been clearly defined. Recent investigations have shown that the noise generated in hot cathode arcs consists of oscillations of several hundred kilocycles superimposed on a background of random noise. The random noise contains a continuous band for frequencies extending from the very low audio range to five megacycles. A suitably placed magnetic field greatly increased the noise level and eliminated the oscillations.

The spectrum obtained from a typical gas tube without magnetic field is shown in Fig. 1A for two discharge currents. The noise level is expressed in db above 10 $\mu v/(kc)^{1/2}$ because, if the bandwidth of the spectrum analyzer is sufficiently

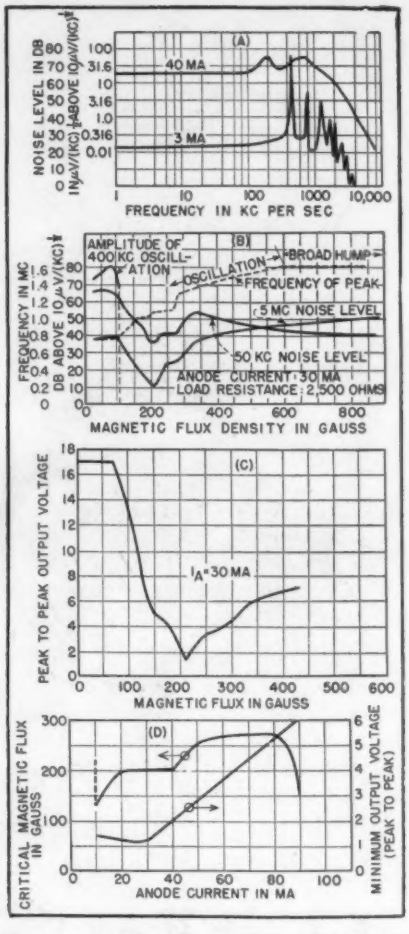
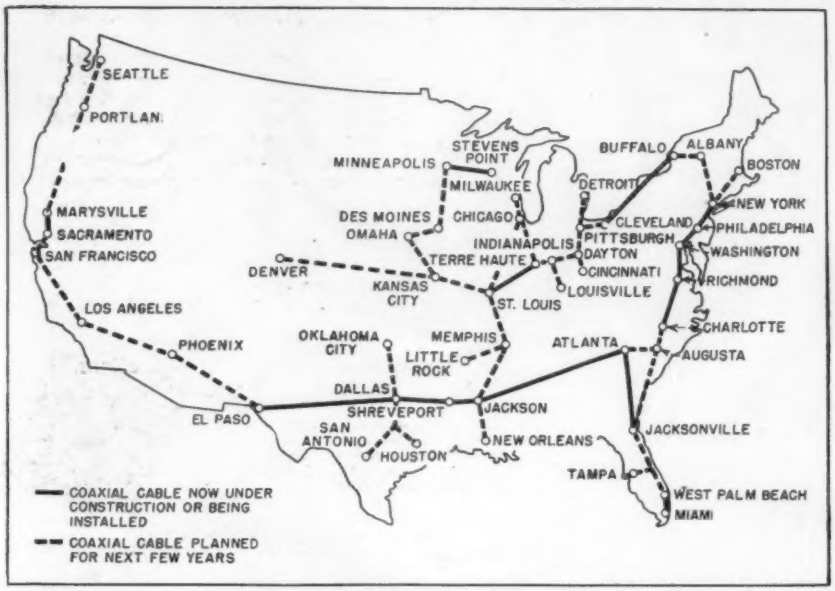


FIG. 1—Noise characteristics of 884 for various operating conditions

Coaxial Cable Television Network Facilities



In addition to the New York to Washington coaxial cable in use since August by East Coast television broadcasters and available on an experimental basis in both directions, A T & T is installing cable facilities as shown on the map. Nationwide television network facilities will ultimately be provided by special repeaters on the coaxial lines, and by radio relay now undergoing trial operation between New York and Boston

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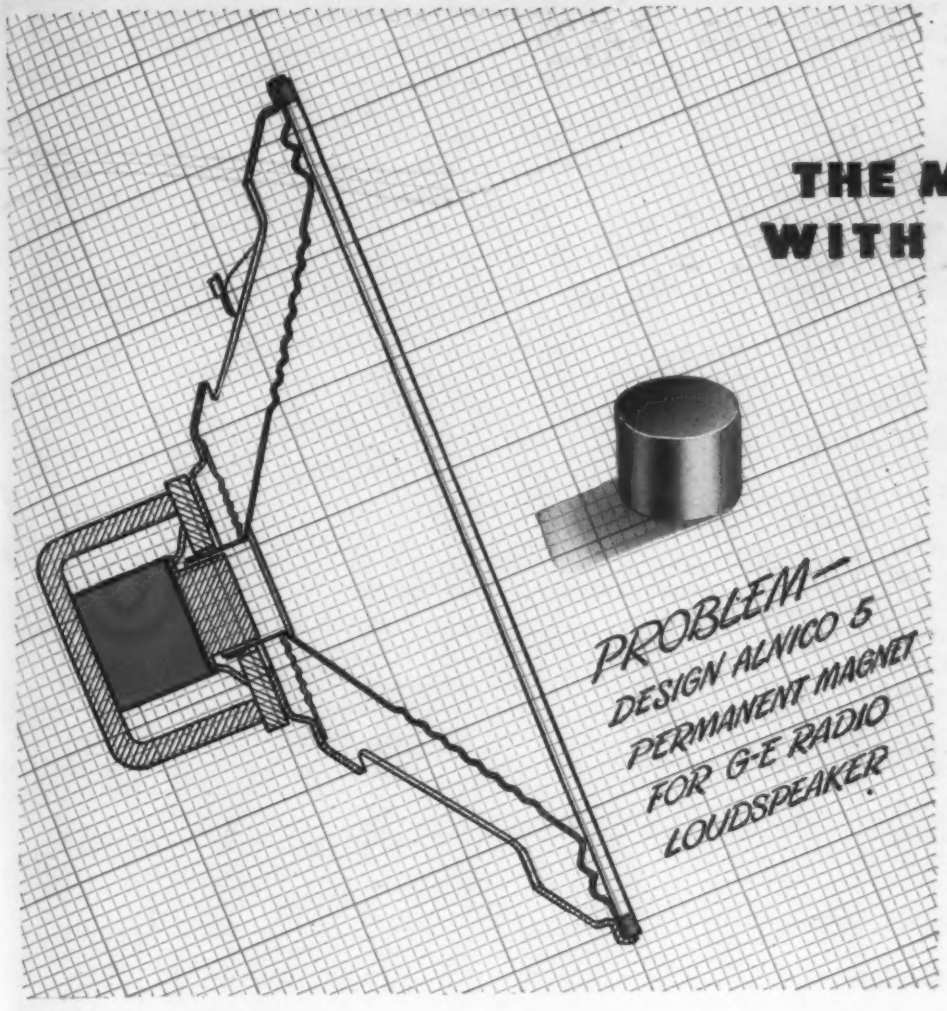

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General Electric's precise quality control methods used throughout magnet production, plus accurate testing and rigid inspection assure you of receiving magnets of the highest uniform quality for your application.

Greater flexibility of magnet design is possible with the many G-E permanent magnet materials now available. The large group of sintered and cast ALNICO alloys has been augmented by the lightweight, non-metallic mixture, VECTOLITE, and by the ductile permanent magnets, CUNICO, CUNIFE and SILMANAL. From such a wide choice of materials, you may now find a magnet better suited for your application or a material which will make possible new designs heretofore impractical or impossible.

General Electric engineers, backed by research and application experience, have acquired years of "know-how" in selecting the best permanent magnet material and properly designing magnets for thousands of products. These engineers are at your service. *Metallurgy Division, Chemical Dept., General Electric Co., Pittsfield, Mass.*

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small, the random noise voltage varies as the square root of the bandwidth.

The two peaks in the curve of Fig. 1A for the higher current represent two distinct oscillations that are not harmonically related. The lower frequency peak is due to plasma ion oscillations; the higher frequency peak is caused by oscillations of positive ions in the potential minimum at the cathode. A summary of the characteristics of a number of hot cathode discharge tubes is presented in Table I. This table gives the frequency and amplitude of the lowest frequency oscillation, as well as the noise level at three selected frequencies. The values are average, there being considerable variation from tube to tube. The last column gives the total rms noise voltage obtained by integrating the spectrum from zero to four megacycles. For comparison, the level of shot noise of a diode for two different currents and with a 3,000 ohm load resistance is presented. The shot noise is much lower than that obtained from the gas tubes.

Table I—Noise Characteristics of Gas Tubes

Tube	Current (ma)	Oscillation		Noise Level			
				decibels[a]			volts RMS
		(kc)	(db)[a]	50 kc	1 mc	5 mc	4 mc
Shot	150	—	—	−14	−14	−14	0.00133
Noise[b]	10	—	—	−26	−26	−26	0.00034
884	40	180	76	66	70	35	0.91
	3	440	76	24	22	−8	—
2A4G	100	450	52	50	24	−5	0.06
WL629	40	210	85[c]	44	58	—	—
WE256A	75	120	51	38	40	−4	0.4
RK62	1.5	650[d]	34	—	1	−10	—
2050	90	150	84	60	51	14	—
	3	90	78	36	14	−10	—
6Q5G	40	550	73	45	50	17	—
FG178A	125	100	78	—	38	—	—
2D21	41	85	94	80[e]	54	18	—
816	125	170	67	60[e]	37	9	—

[a] Zero level is 10 $\mu v/(kc).^{1/2}$
[b] Temperature limited diode with 3,000 ohm plate resistor.
[c] Second harmonic amplitude is 90 db.
[d] Probably another nonharmonic peak below 100 kc.
[e] Approximate.

Effect of Magnetic Field

If a transverse magnetic field is applied across the discharge and the field strength gradually increased, the spectrum of noise undergoes marked changes. Figure 1B shows the change observed in an 884. For this particular tube the amplitude of the low frequency oscillation at 400 kc increased slightly for low magnetic field strengths and then disappeared with no change in frequency as the field was further increased.

The cathode oscillation is differently affected by the magnetic field. The frequency of the peak noise increases with increasing magnetic field, and the spectrum in the vicinity of the peak broadens so that eventually a distinct oscillation is no longer observed. The noise at 50 kc and 5 mc go through a minimum at 210 gauss and then increase. The ultimate level of the 5 mc noise is about 12 db higher than the zero field level.

It is interesting to note that there is an optimum value of magnetic field for which the total variational voltage is a minimum, as shown in Fig. 1C. This optimum value of field is dependent on the current as is the minimum value of the peak-to-peak voltage, as shown in Fig. 1D. Because of variations between tubes, the exact value of the optimum field must be found experimentally for any given tube. This property of reducing the variational voltage has been very useful in control circuits where other tubes are subjected to undesirable random triggering under the influence of a conducting gas tube.

Table II—Noise with Transverse Magnetic Field

Tube	Current (ma)	Flux Density (Gauss)	Noise Level				Type[b]
			(peak volts)	decibels[a]			
				100 kc	1 mc	5 mc	
6D4	5	375	8.2	63	76	38	B
(2C4)	5	720	—	66	76	43	
	20	375	—	70	77	53	
884	45	1,050	5.6	56	62	48	B
2A4G	100	2,000	8.3	60	60	40	A
WL629	40	2,500	4.4	71	69	43	A
WE256A	75	2,000	—	65	58	33	B
RK62	7	620	—	60	57	42	C[d]
6Q5G	40	2,500	—	55	63	37	C[d]
WE323A	100	1,800	—	62	44	8	A
2050	75	500	—	74	47	13	[d]
FG178A	200	960	9.9	82	70	43	A
2D21	41	1,200	5	72	70	47	[e]
	30	700	5	70	64	46	[f]
GL546	13	740	—	68	70	48	

[a] Zero level is 10 $\mu v/(kc).^{1/2}$
[b] See Fig. 2B.
[c] Standard RRL Noise Unit, Maximum is 80 db at 700 kc.
[d] Oscillations not suppressed.
[e] Anode to cathode noise.
[f] Grid to anode noise.

The general shape of the spectrum obtained from a gas tube depends on the type of tube. Figure 2A shows spectra of several types of tubes with magnetic fields. The noise levels are compared with the noise levels from a 931A electron multiplier phototube and a temperature-limited diode.

Shape of the spectrum is determined by tube geometry. Three general types of structure are found in commercial tubes as shown in

(Continued on p 196)

Hyflux Links Electronics and Mechanics

The new Hyflux magnetic tape has changed sound recording from a mechanical operation to a combined electronic and magnetic circuit with mechanical driving mechanism to attain unexcelled reproductive quality. The elimination of mechanical noise inherent in previously used sound recording techniques is a major factor in the utility and flexibility of this new medium. Permanent magnets have been useful for many years in the field of sound in transforming mechanical energy into electrical energy, but the introduction of Hyflux, which is a finely divided magnetic material, establishes a new transformation—that of electrical-to-magnetic-to-electrical energy. The result is a high-fidelity, noise-free, continuous recording adaptable to a wide field of application. Features of instantaneous and repetitious erasure, visual and audio editing, as well as permanency attributable to the high coercive force of the magnetic material, and durability due to the choice of paper used combine to offer the development engineer one of the most versatile tools which he has encountered for many years. Our engineers, experienced through several years' development work on Hyflux Magnetic Tape, will be glad to consult with you on any technical applications which you consider feasible. Write today for our engineering bulletin EBT 101. A few of the uses for which Hyflux is currently being tested and which indicate favorable reactions are: **1. Recording of audio signals or pulses of any duration or wave shape. 2. Seismograph investigation. 3. Memory record for electronic calculating machines. 4. Retention of telegraphic signals. 5. Multiple single-tone reproduction as used in electric organs. 6. Radio transcriptions for Broadcast Studios. 7. Sound on film. 8. Control signals for industrial machines and safety devices. 9. Continuous advertising or announcing equipment. 10. Home and amateur recording. 11. Business office and conference use.**

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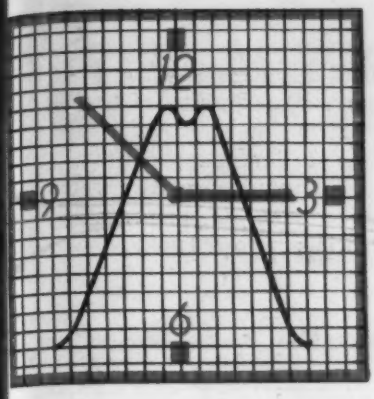

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3. Vernier frequency control of 100 kc allows zero beat calibration of main tuning dial or for vernier frequency adjustment about main dial frequency setting.
4. Output Impedance 1 ohm to 2,500 ohms.
5. Voltage regulated supply for internal oscillator stability.

MODEL 205TS

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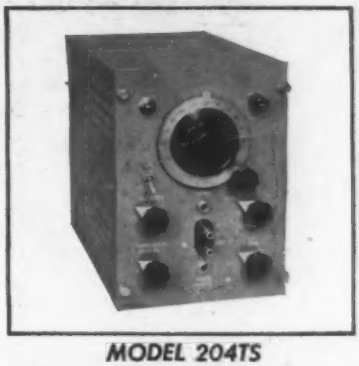
1. Frequency range from 20 kc to 500 kc.
2. Linear frequency sweep deviation adjustable from 0 to 70 kc peak to peak.
3. Low pass filter in the output to minimize spurious output frequencies.
4. Output impedance constant 200 ohms.
5. Output attenuation: 5-step ladder type — 20 db per step.



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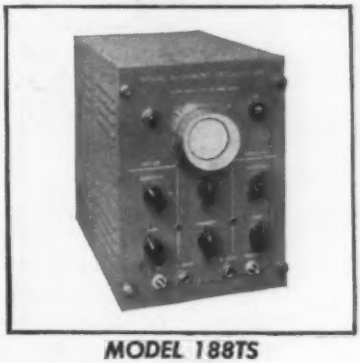

MODEL 188TS

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HARVEY RADIO LABORATORIES, INC.

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NEW PRODUCTS

Edited by A. A. McKENZIE

New equipment, components, packaged units, allied products; new tubes. Catalogs and manufacturers' publications reviewed.

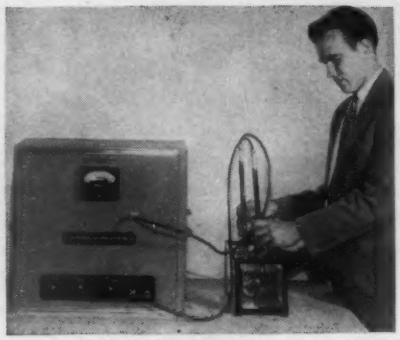
Engineers' F-M Receiver (1)

RADIO ENGINEERING LABORATORIES, 35-54 Thirty-Sixth St., Long Island City 1, N. Y. A new dual-band f-m receiver covering the frequencies

42-50 and 88-108 megacycles has just been released for use by engineers, broadcast stations, and others requiring a stable, high-fidelity means of monitoring or checking performance of f-m transmitters. Model 646 is the standard version, but modifications are available for rack mounting, use with a school public address system, and in cars making surveys or field measurements. The receiver has three i-f stages, two limiters and 10 watts of audio output. High sensitivity and low audio distortion are featured.

Ultrasonic Tester (2)

GENERAL ELECTRIC CO., Schenectady, N. Y. A new materials tester indicates the presence of voids, cracks, porosity and other internal flaws in metals, plastics, and ceramics by means of ultrasonic waves sent through the specimen under test. The instrument consists of a complete wide-band ultrasonic transmitting-receiving system having a high-frequency generator, a crystal transducer to produce ultrasonic vibrations, and a second transducer to convert received mechani-



cal energy into electrical signals. Internal flaws produce measurable decreases in total transmission as indicated by a meter.

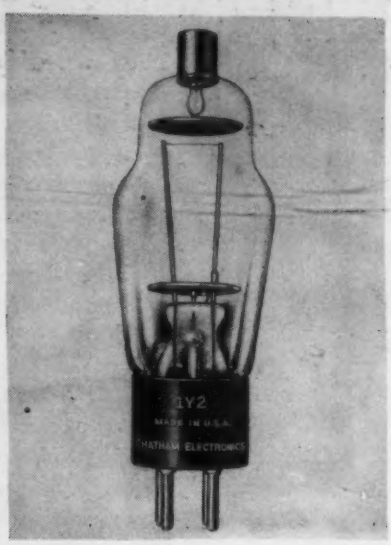
Tape Sound Recorder (3)

INDIANA STEEL PRODUCTS CO., Valparaiso, Ind. The portable recorder illustrated includes recording and playback facilities, is completely selfcontained, and weighs about 30

pounds. The recording medium is a new magnetic tape, called Hyflux, consisting of particles of a material that approaches Alnico in magnetic properties. This material is firmly affixed to a paper tape.

Television Rectifier (4)

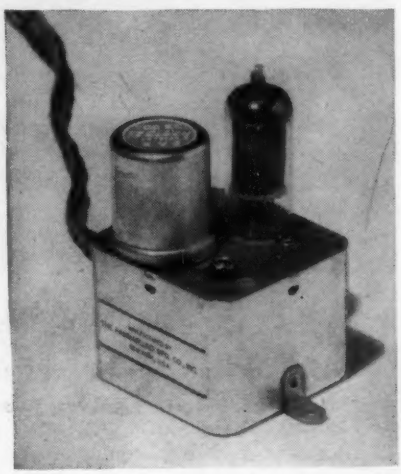
CHATHAM ELECTRONICS, 475 Washington St., Newark 2, N. J. The type 1Y2 is a high-voltage rectifier de-



signed for anode supply on direct view or projection type television tubes. Peak inverse voltage rating is 50 kv. Filament voltage is not critical and can fluctuate between 1.0 and 1.65 volts. Filament is amply rugged for 60-cycle operation and requires low filament power, making it equally adaptable to an r-f filament supply. Interelectrode capacitance and absence of back emission prevent undue loading of the oscillatory circuit in r-f applications. Two tubes deliver 50 kv d-c in a voltage doubler circuit or 25 kv d-c singly.

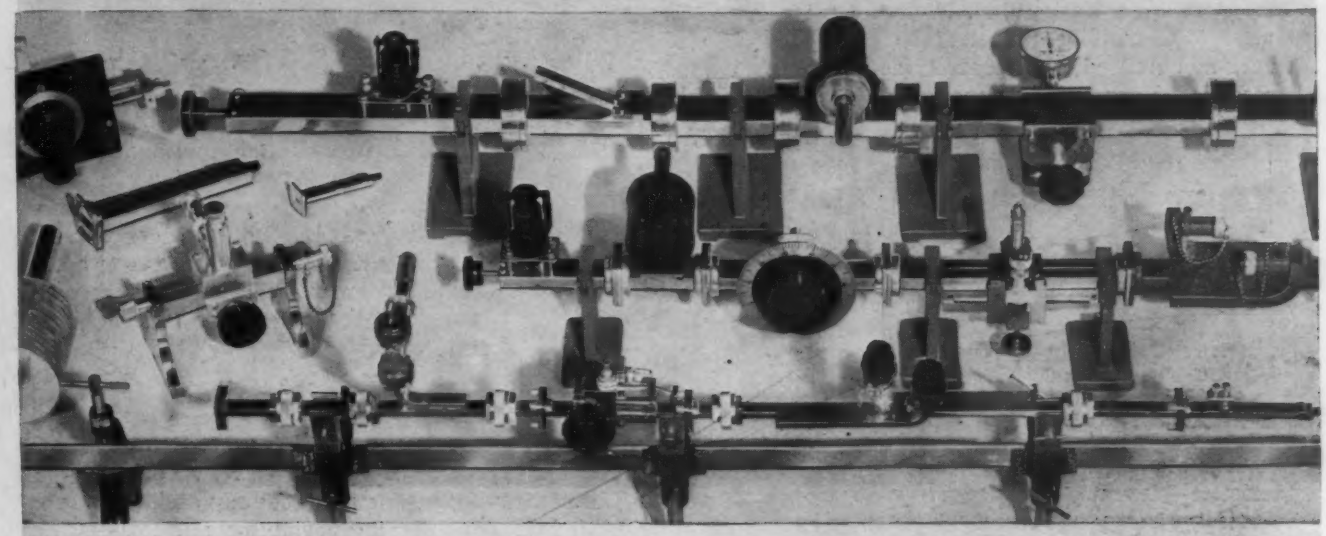
Receiver Frequency Standard (5)

THE HAMMARLUND MFG. CO., Inc., 460 West 34th St., New York 1, N. Y. Designed particularly to aid radio amateurs to conform to legal requirements by maintaining an accurate method of measuring trans-



DE MORNAY · BUDD STANDARD TEST EQUIPMENT

For Precision Measurements in the Microwave Field



The complete line of De Mornay·Budd standard test equipment covers the frequency range from 4,000 mcs. to 27,000 mcs. It provides all R. F. waveguide units necessary for delicate, precision test work requiring extremely high accuracy in attenuation measurements, impedance measurements, impedance matching, calibration of directional couplers, VSWR frequency measurements, etc.

To eliminate guesswork, each item of this De Mornay·Budd test equipment is individually tested and, where necessary, calibrated, and each piece is tagged with its electrical characteristics. All test equipment is supplied with inner and outer surfaces gold plated unless otherwise specified.

NOTE: Write for complete catalog of De Mornay·Budd Standard Components and Standard Bench Test Equipment. Be sure to have a copy in your reference files. Write for it today.

The three test set-ups illustrated above include:

- Tube Mount
- Flap Attenuator
- Frequency Meter
- Calibrated Attenuator
- Tee
- Stub Tuner
- Tunable Dummy Load
- Standing Wave Detector
- Type "N" Standing Wave Detector
- Directional Coupler
- Hight Power Dummy Load
- Cut-Off Attenuator

Stands, etc.

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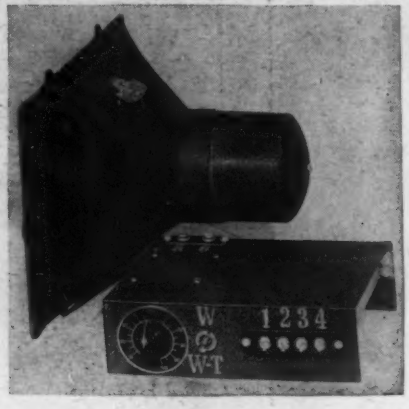
DE MORNAY • BUDD INC., 475 GRAND CONCOURSE, NEW YORK 51, NEW YORK. CABLE ADDRESS "DEMBUD," N. Y.

mitter frequency, the FS-135-C supplies 100-kc markers throughout the tuning range of a communications receiver. The tiny unit consists of an ingenious circuit and special silver-plated spring-suspended 100-kc crystal. A slight variation of tuning is provided so that the circuit can be set to zero beat with signals from WWV.

Tweeter and Network (6)

ATLAS SOUND CORP., 1447 39th St., Brooklyn 18, N. Y. The model HF-1 tweeter is flat within plus or minus 6 db from 1,200 to 14,000 cycles with the frequency-dividing network furnished. A separate woofer



extends the range down to 50 cycles. The speaker handles 20 watts of speech or music and has a horizontal distribution of 80 degrees and vertical coverage of 40 degrees.

F-M Adapter (7)

STROMBERG-CARLSON CO., Rochester 3, N. Y. The Driscoll f-m adapter is a simple device, listing for $6.35, that has been designed for use on all prewar Stromberg-Carlson f-m receivers to adapt them for reception of signals in the new band. At present, the equipment is available only through distributors who make a nominal installation charge, and in some cases, modify the receiver slightly.

Vest-Pocket Earphone (8)

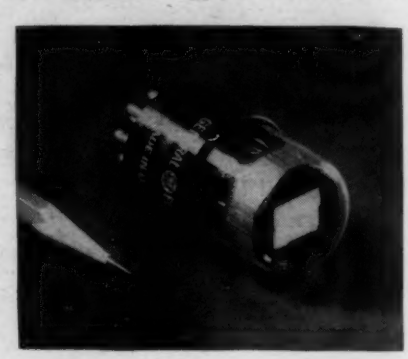
THE BRUSH DEVELOPMENT CO., 3405 Perkins Ave., Cleveland 14, Ohio. The model BA-201 insert-type earphone is manufactured for use with personal vest-pocket radio receivers. It is small (1⅛ inch diameter and ⅛ inch thick) and light in weight (¼ ounce). Using a light-weight Bimorph crystal element, normal loudness results when the receiver is driven with only 1 volt and a power of 10 microwatts. Owing to its rugged construction, a maximum of 50 volts may be applied without damage to the earphone. Its impedance is 120,000 ohms at 1,000 cycles so that no output transformer or choke is required to match to the plate circuit of the output tube.

Instrument Testing Supplies (9)

ARTHUR E. BOOTH COMPANY, 210 West Seventh Street, Los Angeles 14, Calif. New packaged power supply units available in light-weight portable or bench models provide a source of a-c and d-c power smoothly adjustable from zero to maximum output range. Both the a-c and d-c output circuits are completely flexible as to connections for convenient routine testing and checking the calibration of a wide variety of instruments and relays. The present line supplies a full range of alternating and direct currents up to 10 amperes, and a-c and d-c potentials up to 750 volts.

Electron-Ray Indicator (10)

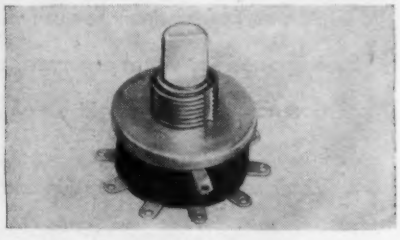
GENERAL ELECTRIC CO., Syracuse, N. Y. The type 6AL7-GT tube is a visual tuning aid for radio receivers. Patterns appear on a fluores-



cent screen at the end of the tube, their shape depending upon the type of circuit used and its adjustment. Deviation from a proper tuning condition can be indicated to the extent of showing on which side of resonance the misalignment occurs.

Rotary Switch (11)

GRAYHILL, 1 North Pulaski Road, Chicago 24, Ill. The new Series 5000 miniature switch is ¾ inch in diameter, 13/32 inch deep, and has a contact pressure of 2½ pounds. It



can be used in circuits passing up to 5 amperes, breaking up to 1 ampere at 110 volts. Featuring 360 degrees rotation in either direction, the switch can be moved from one position to another by turning through the least number of positions, as from position 1 to 10 without going through positions 1, 2, 3,

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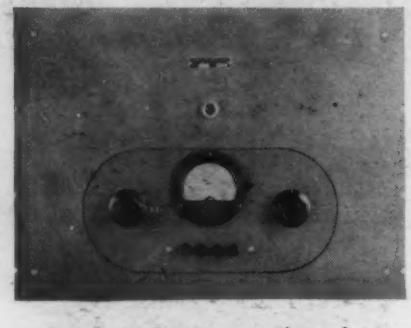
etc. Or, if desired, stops can be placed to allow rotation only through a given number of positions.

Recording Amplifier (12)

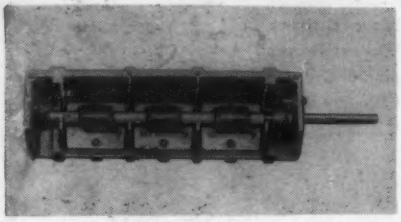
PRESTO RECORDING CORP., 242 West 55th St., New York 19, N. Y. The type 92A amplifier illustrated is rack-mounted with all controls accessible. Four pushbuttons select



various standard recording characteristics—normal response, NAB vertical, NAB lateral, and 78 rpm lateral. Output level and tube plate currents are indicated by a single meter controlled through a selector switch. Frequency response is 20 to 17,000 cycles within 1 db.

Inductive Tuner (13)

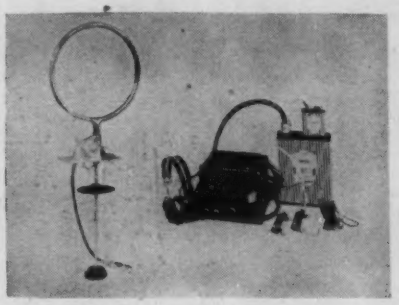
P. R. MALLORY AND CO., Inc., 3209 E. Washington St., Indianapolis 6, Ind. An infinitely variable inductance in the range 44 to 216 megacycles is covered in 3,600 degrees



of rotation of the shaft of the unit illustrated. Several inductors can be ganged for use in television and f-m receiving equipment. The unit can be hand or motor driven.

Range and Loop Receiver (14)

LEAR, INC., Grand Rapids, Mich. The new AMRL-1 radio range receiver and aural-null loop combination are dry-battery powered. The



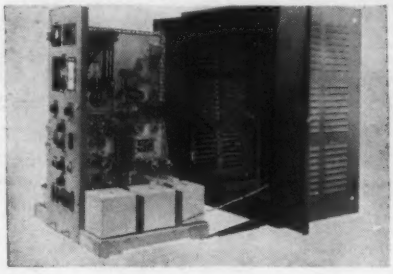
receiver tunes aircraft range beacons in the frequencies 195 to 405 kilocycles. The equipment is simple to install, weighs 12½ pounds, and sells for $159.50.

Fiberglas Tubing (15)

BENTLEY, HARRIS MFG. CO., Dept. P7, Conshohocken, Pa. Samples of Ben-Har Fiberglas tubing are available from the company in grade A with a voltage breakdown strength of 7,000 volts and grade B for 4,000 volts. The nonfraying flexible insulating tubing is supplied in all standard sizes in various colors.

VHF Transmitter (16)

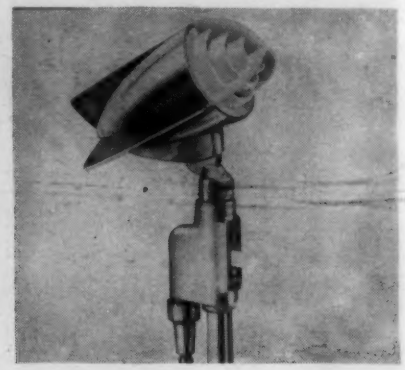
RADIO RECEPTOR CO., Inc., 251 W. 19th St., New York 11, N. Y. The type TV-50-A vhf transmitter can be supplied for any frequency in



the range 100 to 162 mc. Power output varies between 50 and 40 watts with increasing frequency. Audio-frequency response is 150 to 4,000 cycles, within 3 db of the 1,000-cycle response. An audio peak limiter is included to prevent overmodulation. A transmission line monitor rectifier is used.

Crystal Microphone (17)

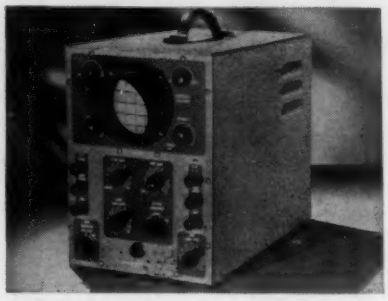
ASTATIC CORP., Conneaut, Ohio. The model 600-S crystal microphone has



relatively high output and wide frequency range, is useful with public address and paging systems, amateur rigs and other communication applications. This new microphone has an overall frequency response that is smooth up to 10,000 c.p.s.

Portable CRO (18)

SYLVANIA ELECTRIC PRODUCTS INC., 500 Fifth Ave., New York 18, N. Y. A new cathode-ray oscilloscope featuring portability and low cost has



been designed for radio set servicing and general service applications. The new type 131 oscilloscope, weighing 18 pounds, is mounted in a cabinet measuring 10¾ in. high, 8⅛ in. wide and 13¾ in. deep. Signal frequency range from 15 to 40,000 cycles is provided with a five-range selection control and a fine frequency control. Visual study of wave form is provided by a 3-in. cathode-ray tube designed for 650-volt deflection plate operation.

UHF Signal Generator (19)

HEWLETT-PACKARD CO., Palo Alto, Calif. The direct-reading type 610A uhf signal generator has a frequency range of 500 to 1,350 mc, and is a valuable laboratory standard for determining gain or align-

(continued on p 216)

NEWS OF THE INDUSTRY

Edited by JOHN MARKUS

Nucleonic news; radar on airliners; heating gets 2,450 mc; new f-m rulings; f-m clinic; taxicab radio survey; Atlanta Conference

IRE Honors Engineers at 1947 National Convention

The Institute of Radio Engineers has issued the following list of honors presented to members for outstanding accomplishments.

The Morris Liebmann Memorial Prize for 1946 was awarded to Albert Rose of RCA for his contributions to television pickup tubes, particularly the image orthicon.

The Morris Liebmann prize for 1947 was awarded to John R. Pierce of Bell Telephone Laboratories for his development of the traveling-wave tube.

Fellowships were awarded to the following: Benjamin De F. Bayly, Frank H. R. Pounsett, Pedro J. Noizeux, Sir Robert Watson-Watt, George P. Adair, G. L. Beers, L. V. Berkner, E. L. Bowles, R. S. Burnap, R. F. Field, D. G. Fink, W. W. Hansen, D. R. Hull, F. V. Hunt, K. G. Jansky, R. D. Kell, C. V. Litton, J. W. McRae, I. E. Mouromtseff, D. E. Noble, R. M. Page, J. A. Pierce, C. A. Priest, W. W. Salisbury, and E. N. Wendell.

Presentation of the awards will be made at the annual banquet Wed. March 5 during the IRE National Convention at the Hotel Commodore in New York City. Guest speaker at the banquet will be Charles R. Denny, Jr., FCC chairman, who will discuss "Frequency Allocations". At the President's Luncheon March 4, Vice-Admiral Charles A. Lockwood will speak on "Electronics in Submarine Warfare".

Mobile Radio on Farm

Construction permits for one land station and one mobile station with 11 units have been granted King Farms Co., Morrisville, Pa. by the FCC. The stations will be used for office-to-car and car-to-car communication on this 6,000-acre truck farm to expedite planting, cultivating, harvesting, and marketing of farm vegetables. The Bell Telephone Co. of Pennsylvania will own, install, and maintain the equipment, but all operating will be done by the King Farms Co. which at peak seasons employs up to 600 workers. The frequency of 156.99 mc is assigned on a temporary basis.

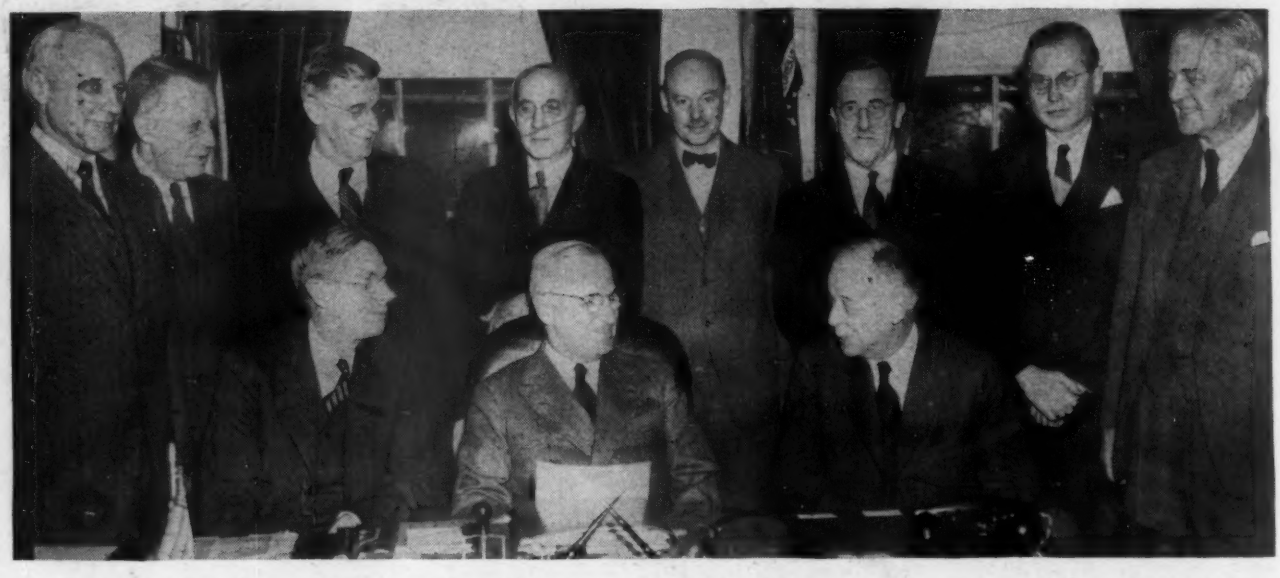
Declassified Papers on Atomic Energy Now Available

THE FIRST 270 atomic energy papers to be declassified by the Atomic Energy Commission or by its predecessor, the Manhattan Engineer District, can now be obtained from the Office of Technical Services of the Department of Commerce at prices ranging from $1 upward depending on length.

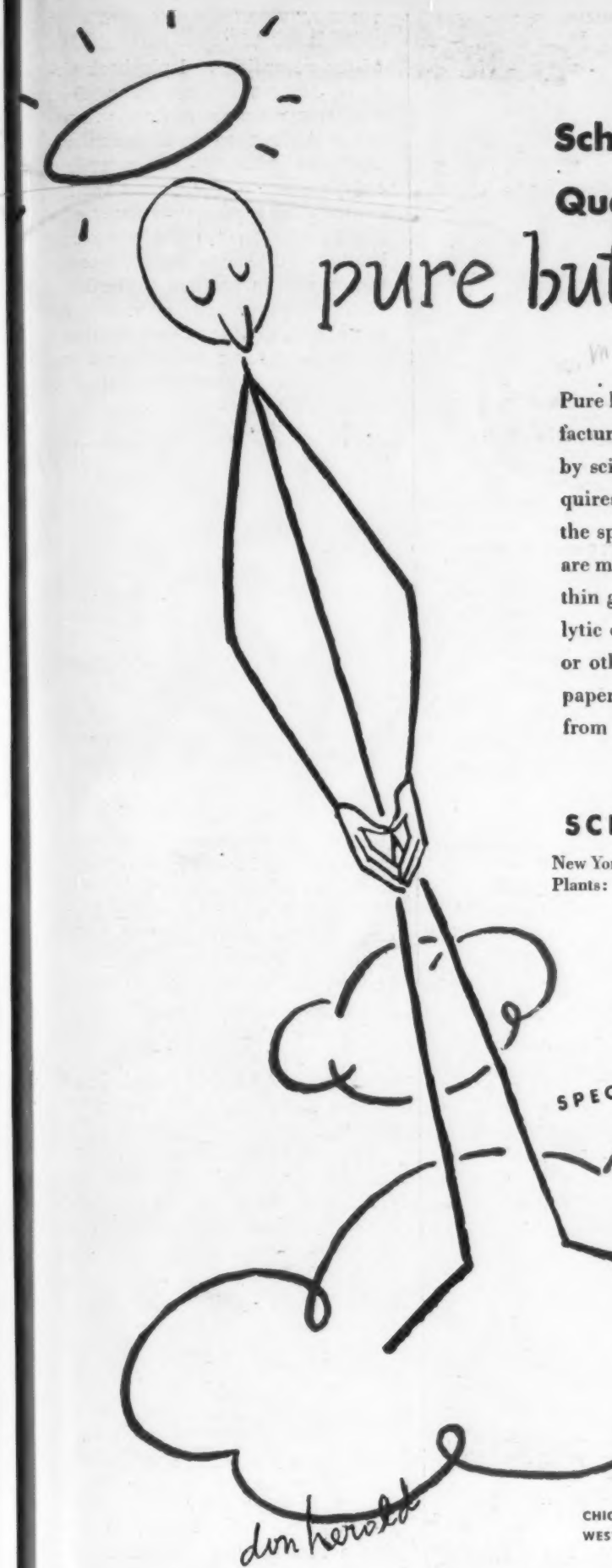
These papers constitute the first sizable release of atomic energy information which has been made since the early days of the war, when a top secret classification was

(Continued on p 256)

CONGRATULATIONS TO TEN KEY SCIENTISTS



For their work in the wartime Office of Scientific Research and Development, President Truman on January 20 congratulated these key scientists. Left to right, seated: Dr. James B. Conant, president of Harvard Univeristy; President Truman; Dr. Alfred N. Richards, chairman of the OSRD committee on medical research. Standing: Dr. Karl T. Compton, president of MIT; Dr. Lewis H. Weed, National Academy of Sciences; Dr. Vannevar Bush, director of OSRD; Dr. Frank B. Jewett; Dr. J. C. Hunsaker of MIT; Dr. Roger Adams of University of Illinois; Dr. A. Baird Hastings of University of Illinois; Dr. A. R. Dochez of Columbia University.



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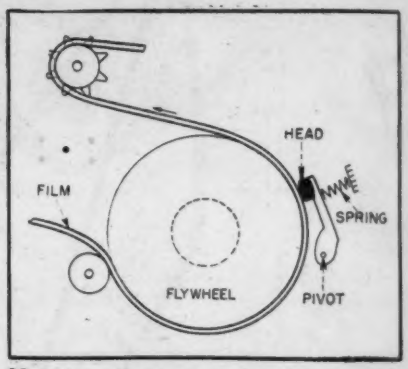
of the recording and playback circuits, erasing is done by a 40-kc oscillator when the switch is in position *A*. In position *B* the microphone, amplifier, and recording equalizer are in the circuit for recording. Some of the oscillator output is also fed to the recording head to provide a high-frequency component. In position *C* the head picks up the magnetic variations in the film. These are first equalized by the playback equalizer, then fed through the amplifier and into the loudspeaker.



Mounting arrangement for the magnetic pickup head. The pressure against the coating is on the order of 0.0001 ounce

An overall frequency response curve for the 16-mm system shows that it is flat within ± 3 db from 50 to 5,000 cycles. At normal recording levels the intermodulation distortion is about 5 percent. The background noise is 35 to 40 db below the program level.

The magnetic coating can also be put on 8-mm film between the sprockets and edge of the film, and has the same dimensions as on 16-mm film.

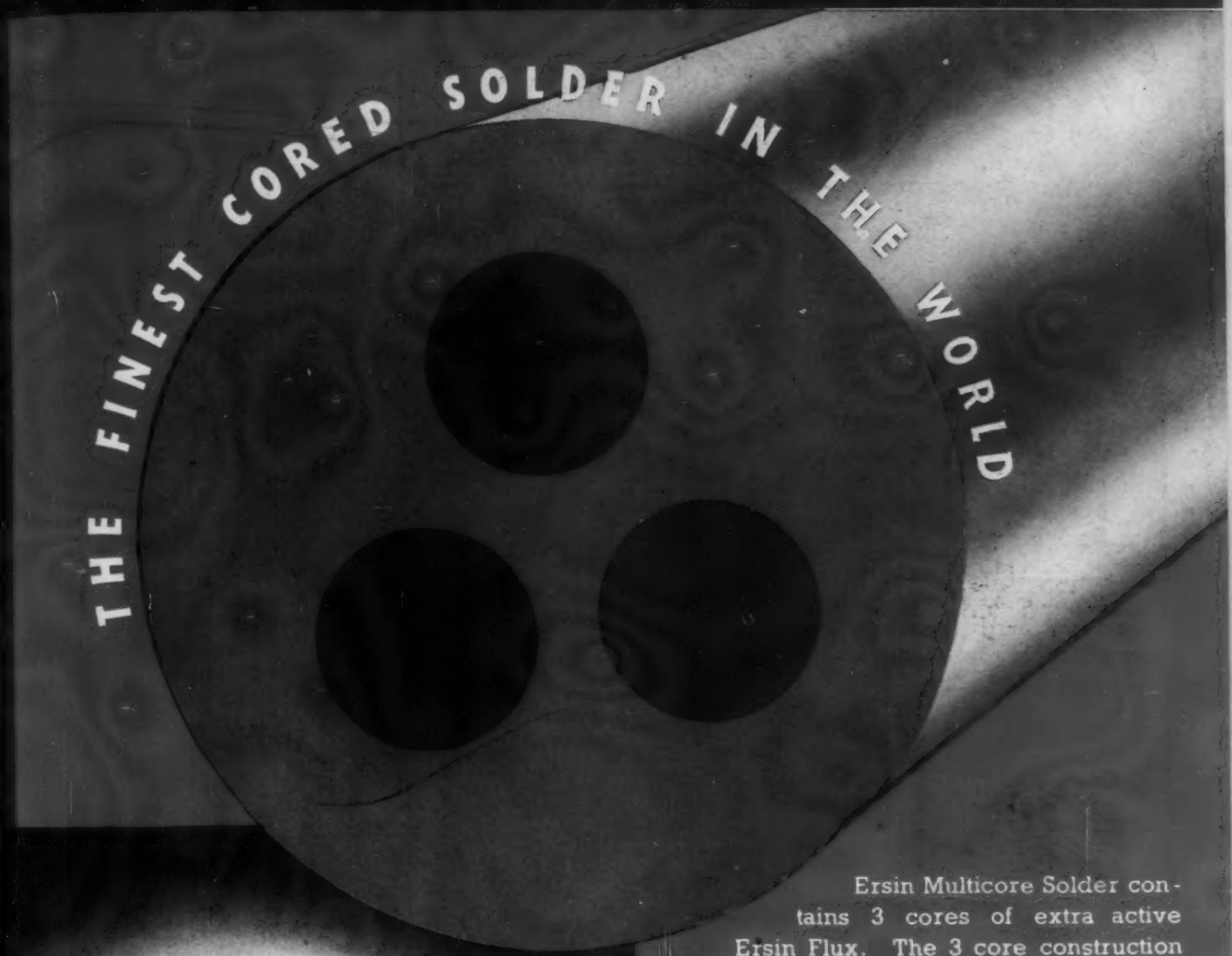
Because 8-mm film moves at half the speed of 16-mm film, its upper frequency limit is about 2,500 cycles. On voice, the sibillants are clear and natural. Quality on music, while not as good as at sixteen-millimeter speed, is comparable to that of low-cost radio receivers. Distortion and signal-to-noise ratio are about the same as at higher speeds.

Soldering Litz Ends

By EMERICK TOTH
Naval Research Laboratory
Washington, D. C.

THE WRITER had occasion to design a receiver for aircraft using

ERSIN MULTICORE



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U.S.A. enquiries to
BRITISH INDUSTRIES CORP., 315 Broadway, New York 7, N.Y.

Canadian enquiries to
SNI-DOR RADIOLECTRIC LTD., 455 Craig Street West, Montreal.

Enquiries regarding other territories to
MULTICORE SOLDERS LTD., Mellier House, Albemarle Street, London, W.1. England.
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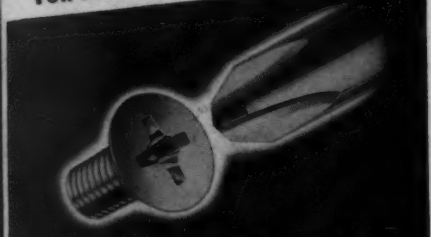

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coils of litzendraht wire. These coils ranged in diameter from 12 inches, wound with litz of about 180 strands of number 38 wire, to little fellows of ½ inch ID using 7/41 litz. Over 150 coils were involved, a total of more than 300 coil ends, thousands of individual strands that must be properly tinned and soldered.

Careful tests were made of the following three methods:

(1) Cautious removal of the silk and enamel from the coil end by abrasion against a relatively soft high-speed rotary wirebrush.

(2) Heating of the coil end in an alcohol or Bunsen-burner flame and subsequent plunging of the hot coil end into alcohol.

(3) Application of a small quantity of a paste of zinc chloride and water to the coil end and heating with a soldering iron, immediately followed by tinning with rosin-core solder while the resulting zinc chloride and enamel mixture was still boiling. The silk insulation was burned and stripped off by a very short exposure to a flame, and subsequent wiping with a rag prior to application of the zinc chloride.

Results of Tests

Method (1) was found to damage individual strands excessively, and did not clean all strands in sizes of litz with many strands, such as 70/38 and 180/38.

Method (2) was difficult to control. Insufficient exposure to the flame resulted in the enamel not cracking off when the hot coil end was plunged into cold alcohol. Overheating caused individual strands to burn off. Even when satisfactory cleaning was obtained, the copper was left so brittle that soldered coil ends would break easily.

Method (3) provides easy and effective tinning. The appearance of the tinned end was neat and clean after the residue of zinc chloride, enamel, rosin, and solder had been wiped off while still hot with a damp rag. The ease of tinning even 180/38 litz suggested that inside strands were not properly coated. Several samples were cut in cross-section but all strands appeared to be clean of enamel and tinned.

Samples were placed in a salt-spray chamber and subjected to the Navy's standard salt-spray test

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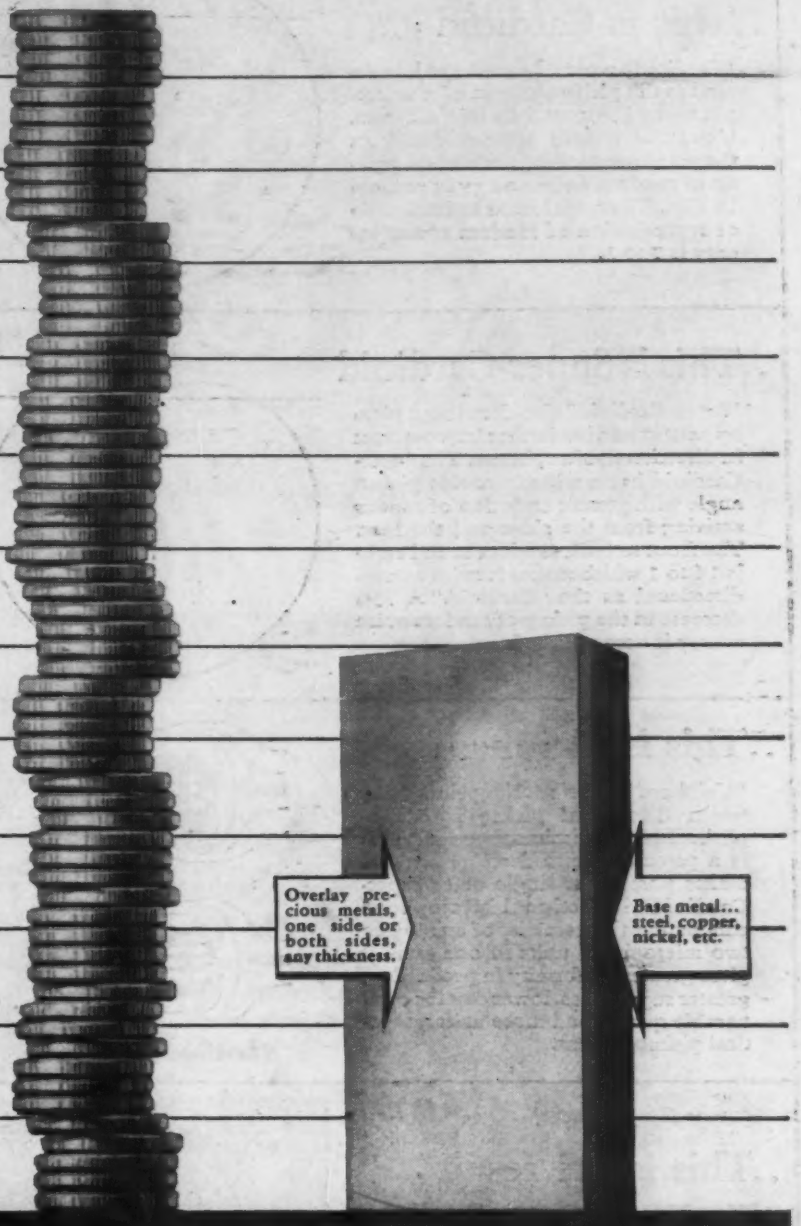

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Because General Plate Laminated Metals . . . sheet, wire and tube . . . are permanently bonded laminations of a thin layer of precious metal to a thicker layer of base metal, they give you precious metal performance at a cost slightly higher than the inexpensive base metal.

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Investigate General Plate Laminated Metals, today. Our engineers are available for consultation on your metal problems. Write:

SHEET . . . Available with precious metal on one side, both sides or wholly covered, inlaid and edge laid in practically any combination of precious to base metal. Base to base metal combinations also available.

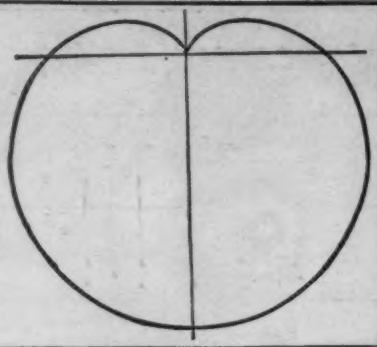
TUBE . . . Solid precious metal; laminated precious to base metal lined, or covered one side or both in a wide range of diameters and odd shapes.

WIRE . . . Shaped, solder filled, channel, solder flushed, squares, flats, ovals and irregular shaped.

GENERAL PLATE DIVISION
of Metals and Controls Corporation
ATTLEBORO, MASSACHUSETTS

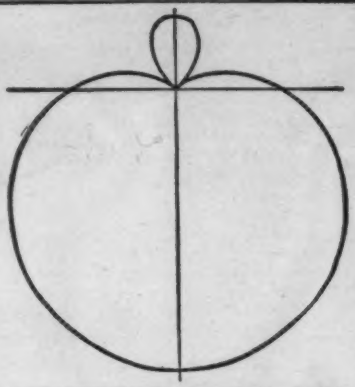
..This is Cardioid

"Cardioid" means heart-shaped. It describes the pickup pattern of a microphone as illustrated in this diagram. Unwanted sounds approaching from the rear are cancelled out and the pickup of random noise energy is reduced by 66%. The actual front to back ratio of reproduction of random sound energy is 7 to 1.



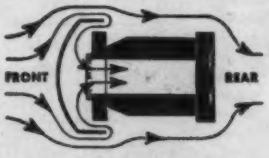
..This is Super-Cardioid

"Super-Cardioid" also describes a pickup pattern and is a further improvement in directional microphones. The Super-Cardioid has a wide front-side pickup angle with greater exclusion of sounds arriving from the sides and the rear. The front to back random sound ratio is 14 to 1 which makes it twice as unidirectional as the "Cardioid." A 73% decrease in the pickup of random noise energy is accomplished.

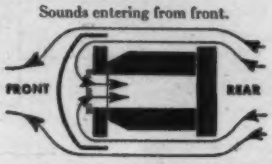


..This is Uniphase

"Uniphase" describes the principle by which directional pickup is accomplished in a single microphone unit. This is a patented Shure development and makes possible a single unit "Super-Cardioid" Directional Microphone eliminating the necessity of employing two microphone units in one case—it gives greater uniformity in production, greater ruggedness, lower cost for comparable quality and more uniform vertical pickup pattern.



Sounds entering from front.

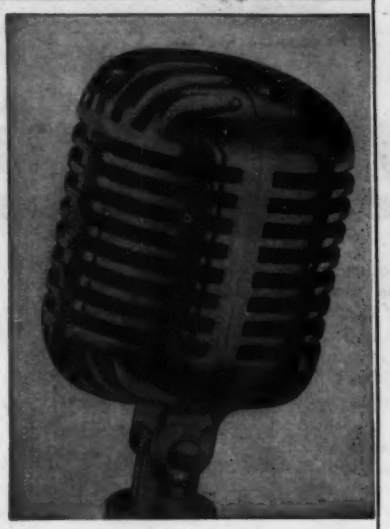


Sounds entering from rear.

..This is the result

The SHURE Super-Cardioid

A decrease in the pickup of random sound energy by 73%—reduction of feedback and background noise—simplification of sound pickup are among the many advantages offered by the Shure "Super-Cardioid" Dynamic. These, plus faithful reproduction, are the reasons why Shure "Super-Cardioid" Microphones are used by more than 750 Broadcast Stations in the United States alone, by our Armed Forces throughout the world, and on thousands of Public Address Systems everywhere.



SHURE BROTHERS, Inc.

Microphones and Acoustic Devices

SHURE

225 West Huron Street Chicago 10, Illinois

Cable Address: SHUREMICRO

for two hours. It was found that except for a light accumulation of powdery salt the samples were in no way affected by the test and all 300 coil ends were processed as outlined in method (3) above.

Eighteen months after delivery, one equipment was examined which had been in service in Panama for a year. No trace of corrosion or any other damage was found.

Zinc chloride is very hygroscopic and should be kept in a suitable well-stoppered glass bottle, with only as much paste prepared at one time as is needed for a few hours use.

Square Loop F-M Antenna

AN EIGHT-ELEMENT square-loop antenna multiplies the power of a transmitter by more than eight times but erecting an 80-foot one atop a 30-story building multiplies the construction problems even more. Such an antenna has been erected for WCTN-FM, Minneapolis, on the Foshay Tower in that city where tons of equipment had to be moved thirty stories above the ground.

First square-loop section of the antenna as it cleared the roof

The highest point in the Twin-Cities area is the Foshay Tower, selected for the Federal eight-element square-loop antenna after a survey of all available locations. The building rises 447 feet above the street, is of steel and stone construction, and is patterned after the Washington Monument. All outside work had to be completed before the

LET THESE WAA DISTRIBUTORS HELP YOU

Save with surplus

The War Assets Administration has appointed a representative group of competent well established distributors to help dispose of war-surplus electronic tubes and equipment. We suggest that you get in touch with the distributor nearest you. He will know the items available and how they can aid in solving your electronic problems.

ELECTRONICS DIVISION
OFFICE OF AIRCRAFT DISPOSAL

WAR ASSETS ADMINISTRATION

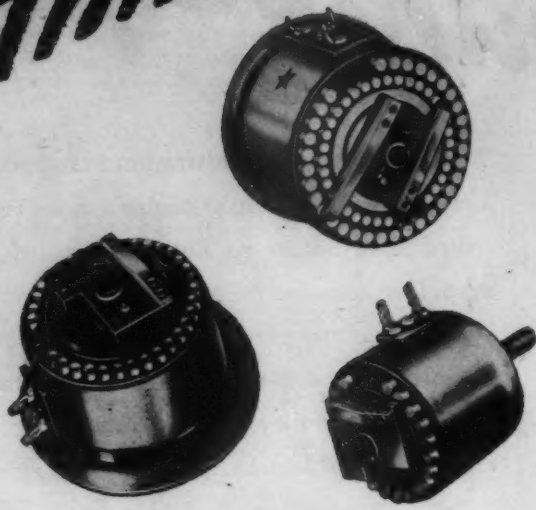
425 Second St., N.W. Washington 25, D. C.

Here is an up-to-date list of WAA approved distributors.

BOSTON, MASS.	
Automatic Radio Mfg. Co., Inc.	122 Brookline Ave.
Technical Apparatus Co.	165 Washington St.
BUCHANAN, MICH.	
Electro-Voice, Inc.	Carroll & Cecil Sts.
CANTON, MASS.	
Tobe Deutschmann Corp.	863 Washington St.
CHICAGO, ILL.	
American Condenser Co.	4410 Ravenswood Ave.
Majestic Radio & Television Corp.	125 W. Ohio St.
EMPORIUM, PENN.	
Sylvania Electric Products, Inc.	
FORT WAYNE, IND.	
Essex Wire Corp.	1601 Wall St.
LOS ANGELES, CALIF.	
Cole Instrument Co.	1320 S. Grand Ave.
Hoffman Radio Corp.	3761 S. Hill St.
NEWARK, N. J.	
Standard Arcturus Corp.	99 Sussex Ave.
Tung-Sol Lamp Works, Inc.	95—8th Ave.
NEW YORK, N. Y.	
Communication Measurements Laboratory	120 Greenwich St.
Electronic Corp. of America	353 W. 48th St.
Emerson Radio & Phonograph Corp.	76—9th Ave.
Hammarlund Mfg. Co., Inc.	460 W. 34th St.
Newark Electric Co., Inc.	242 W. 55th St.
Raytheon Mfg. Co.	60 E. 42nd St.
Smith-Meeker Engineering Co.	125 Barclay St.
SALEM, MASS.	
Hytron Radio & Electronics Corp.	76 LaFayette St.
SCHENECTADY, N. Y.	
General Electric Co.	Bldg. 267, 1 River Rd.
WASECA, MINN.	
E. F. Johnson Co.	206—2nd Ave., S. W.

945

Announcing



SHALLCROSS VARIATEN

VARIABLE ATTENUATORS

Quality-proved on the world's most exacting applications

Now . . . the foremost Attenuator line . . . Variaten . . . is being engineered and produced by a national leader in precision electronic equipment . . . SHALLCROSS.

To a line already popular with broadcast, communication, recording and movie-sound equipment studios, has been added the complete facilities of this leading producer of fine electrical measuring instruments, selector switches and precision wire-wound resistors.

SHALLCROSS VARIATEN ATTENUATORS employ wire-wound resistors. Stone-lapped brush and contact surfaces assure complete overall contact for minimum noise level and lengthened service life. Types include ladder mixers, bridged and straight "T" attenuators, bridged and straight "H" attenuators, grid control potentiometers, loud speaker volume controls, turn-table faders, D.B. and V.U. meter range-extenders, and fixed pads for every purpose. Special designs made to specifications.

Shallcross Manufacturing Co.

DEPT. E-37, COLLINGDALE, PA.

arrival of Minnesota's bitter winter.

Planners of the station engaged the original designer of the Foshay Tower and its original builder because they were thoroughly acquainted with its construction. An unfinished elevator shaft from the basement to the 30th floor was used as the route to the roof. Through this shaft the antenna sections, equipped with their loops and other components, were hoisted to point of final assembly beneath the peak.

First step in the erection was to cut an opening large enough to accommodate the over-all width of the antenna loops through the tip of the tower. The top section of the antenna, surmounted by a 300-mm aircraft warning beacon, was then assembled and raised through the opening by a system of steel cables attached to hand-operated winches.

Viewed from underneath, while another section is added to the antenna

A second section was added to the first and both were pushed through the opening in the peak. This process of building from the bottom was continued until all eight sections and their associated components were in place and the completed antenna was in position.

The final step was to anchor the base of the antenna to a 27-foot inner support tower, fastened to the main cross beams of the building.

The new antenna is operating at 97.1 mc for WTCN-FM, which holds one of the highest effective radiated power ratings in the United States. Present operating power is three kilowatts into the antenna from a Federal FMTB 3000 f-m transmitter. This produces an effective ra-

UNFINISHED BUSINESS
SPECIFICATIONS
THIS EQUIPMENT IS DESIGNED TO OPERATE AT 115V-AC-60 CYCLES
SOLA
This equipment is designed to operate at
115 V-AC
60 cycles
As a protection against voltage fluctuations a CONSTANT VOLTAGE TRANSFORMER has been built-in as a component part of this equipment. Rated performance will therefore be maintained at all times, regardless of input voltage fluctuations as great as ±15%.
HAVE YOU FORGOTTEN THAT YOUR CUSTOMER'S LINE VOLTAGE WILL FLUCTUATE?

115 Volts . . . ± 15%. Is that what you meant when you specified the label rating. That's what your equipment will be up against when it's at the mercy of commercial line voltages.

If your equipment will not stand that tolerance, you're saddling your customers with a serious problem and one which few will understand. Your equipment will be blamed for any breakdown or unsatisfactory performance—not the fluctuating voltage that caused it.

You can relieve your customers of this problem, eliminate costly service calls . . . and . . . accomplish all this at an actual saving in original design costs. The answer is . . . "include a SOLA Constant Voltage Transformer as a built-in component."

SOLA Constant Voltage Transformers are available in 31 standard designs in capacities from 10VA to 15KVA . . . or special units can be custom built to your specifications. Whether your product is designed for home, science or industry—Constant Voltage is *your* problem. May we make recommendations for your equipment?

This book provides the answer to *your* Constant Voltage problem.

Ask for Bulletin DCV-102

SOLA *Constant Voltage* TRANSFORMERS

Transformers for: Constant Voltage • Cold Cathode Lighting • Mercury Lamps • Series Lighting • Fluorescent Lighting • X-Ray Equipment • Luminous Tube Signs Oil Burner Ignition • Radio • Power • Controls • Signal Systems • etc. SOLA ELECTRIC COMPANY, 2525 Clybourn Avenue, Chicago 14, Illinois

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IRN

A New Technical Bulletin, describing many desirable characteristics of Mepham IRN magnetic iron powders, is now available.... Send for your copy. It contains 28 pages of comprehensive data, including performance graphs, on 10 different types of IRN magnetic iron powders (hydrogen reduced) for high-frequency cores, core material, telecommunication and magnetic applications. Useful frequency ranges—.01 to 200 megacycles and up.

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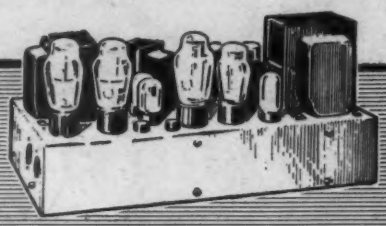

ZERO DISTORTION ?

NOT QUITE—but very close to it

The BROOK HIGH QUALITY AUDIO AMPLIFIER

BROOK

BROOK ELECTRONICS
Inc.
34 DeHart Place
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Designed by LINCOLN WALSH

Distortion is reduced to extremely low levels previously unattainable.

The Brook amplifier uses triode tubes exclusively, a patented circuit, and has 30 watts power output.

Cabinet or rack mounting. *Prompt delivery.*

See it at the I. R. E. Show
Grand Central Palace *March 3, 4, 5, and 6.*

Soundcraft
and
BLANK RECORD ENGINEERING

•

Every so often a new name appears in every line of business. Not yet a year old Soundcraft is new in name only to the blank record field.

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To Soundcraft engineers the business of manufacturing discs is no novelty. Directly or indirectly, almost every recordist has benefitted in some way from past contributions of Soundcraft engineers.

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These men for many years have been associated not only with disc recording but also with film techniques. They are designers and builders of recording equipment. As disc coating engineers they know recording lacquer. They know recordists needs and how to satisfy them.

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By reason of the collective experiences of the past, in addition to sound planning for the future, Soundcraft will continue to offer the very best in high fidelity recording discs.

The 'Broadcaster'
8" 10" 12" 16"
The 'Playback'
6½" 8" 10" 12" 16"
The 'Audition'
6½" 8" 10" 12" 16"
The 'Maestro'
12" 13¼" 17¼"

Soundcraft

REEVES SOUNDCRAFT CORP.
10 EAST 52 ST., NEW YORK 22, N.Y.
PROGRESS ALONG SOUND LINES

NEW... Simpson Model 305RC Tube-Tester with "No Backlash"* Roll Chart

With the addition of the new Simpson "No Backlash"* Roll Chart to the 1947 version of our Model 305, this famous instrument becomes beyond question the finest tube-tester on the market in its price range. Read the description of this new Roll Chart in the panel below.

Model 305RC provides for filament voltages from .5 volts to and including 120 volts. It tests loctalc, single ended tubes, bantams, midgets, miniatures, ballast tubes, gaseous rectifiers, acorn tubes, Christmas tree bulbs, and all popular radio receiver tubes.

Like other Simpson tube-testers, the Model 305RC incorporates 3-way switching which makes it possible to test any tube regardless of its base connections or the internal connections of its elements. This method, the result of exhaustive research and expensive construction, protects the Model 305RC against obsolesence to a degree not enjoyed by competitive testers. No adapters or special sockets are required. In addition to having a complete set of sockets for every tube now on the market, this tester has a spare socket, to provide for future tube developments.

The Model 305RC has provision for testing pilot lamps of various voltages as well as Christmas tree bulbs. It tests gaseous rectifiers of the OZ4 type—also tests ballast tubes direct in socket for burnouts and opens. Has neon bulb of proper sensitivity for checking shorts. This tube-tester is fused, and has the latest improved circuit. It provides for line adjustment from 100 to 130 volts, with smooth vernier control.

Model 305RC is distinguished for its beautiful exterior. It has a two-tone metal panel in red and black on a satin-finished background. Sockets and controls are symmetrically arranged for quick operation. The large, modern, fan-shaped instrument has an exceptionally long scale. It has "good" and "bad" English markings, also a percentage scale for matching and comparing tubes. Cases, both portable† and counter style, are made of strongly built hardwood, durably and beautifully finished.

Size, 11"x11"x6". Wt. 10 lbs. Shipping wt., 15 lbs.
Dealer's net price, portable or counter model.....**$59.50**
For 60 cycle 115 volt current only.
For 220 volt or 60 cycle, add..... **7.50**
Standard Model 305, with book-type speed chart **49.50**

Counter Model 305RC. Same instrument as portable model, but set in fine walnut finished hardwood case, with tilted, easy-to-use panel.

†Finished hardwood cases are standard on portable models. When these are not available, the instrument is housed in attractive simulated-leather covered case.

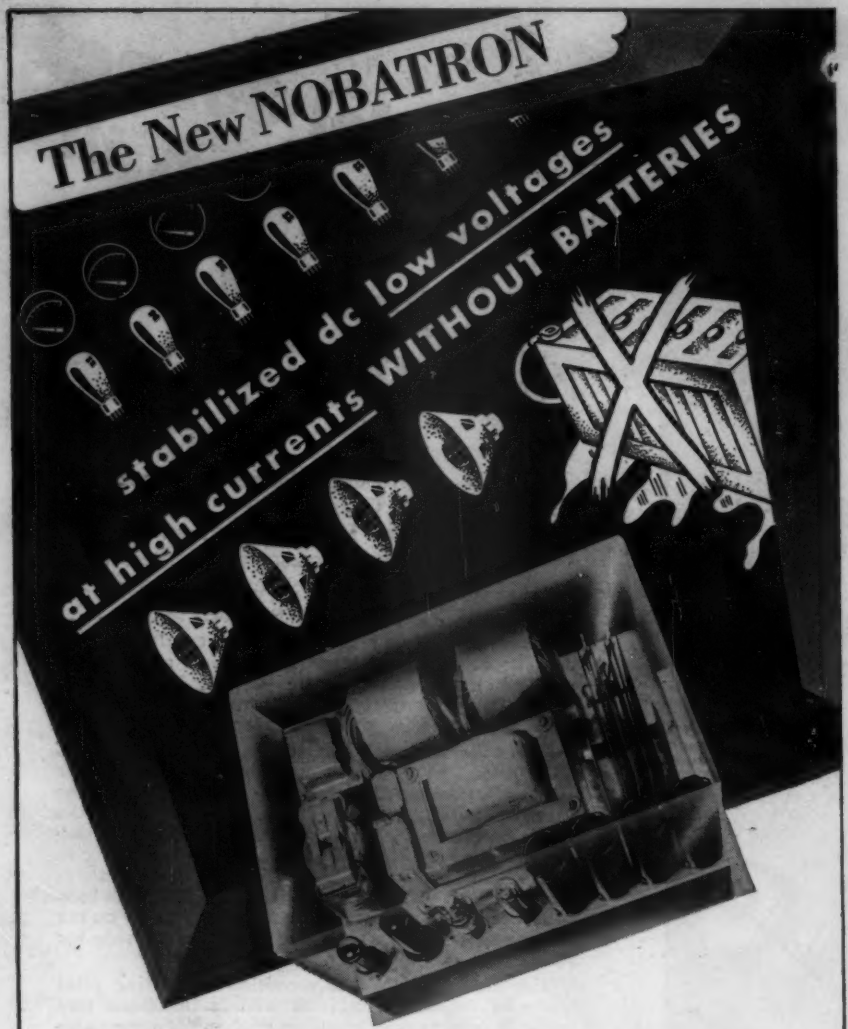
***6 Exclusive Features Make This the Finest Roll Chart Ever Designed for Tube-Testers . . . . .**

- "No Backlash" feature of this Roll Chart automatically takes up all slack in the paper chart and, by keeping it in constant tension, makes it impossible to turn the selector wheel without turning chart. Gives precision selection at all times. Also prevents chart from tearing or getting out of alignment.
- Gearing is such that only 6 turns of selector wheel will run the entire length of the 12½ ft. chart.
- Easy to read. The clear Lucite window is just wide enough to show 2 tube settings, or both settings on a multi-purpose tube.
- Entire unit removable by taking out four screws. Just lift from receptacle to make new entries or install new chart.
- Chart ingeniously fastened to rollers, affording easy replacement and constant alignment.
- Rigid, light-weight construction. Gear driving mechanism incorporates heavy-duty precision brass gears and parts.

Simpson

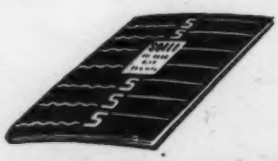
INSTRUMENTS THAT STAY ACCURATE

SIMPSON ELECTRIC COMPANY
5200-5218 W. Kinzie Street, Chicago 44, Illinois
In Canada, Bach-Simpson, Ltd., London, Ont.



- **The Sorensen NOBATRON provides a new source of DC voltages regulated at currents previously available only with batteries.**
- **Six standard NOBATRON models operate on a 95-125 volt AC source of 50 to 60 cycles and provide currents of 5, 10, and 15 amperes at output voltages of 6, 12, or 28.**
- **Ideally suited for critical applications where constant DC voltages and high currents are required, the NOBATRON maintains a regulation accuracy of ½ of 1%, RMS of 1% and has a recovery time of 1/5 of a second.**

● *Investigate the many advantages of Sorensen regulators applied to your unit. Write today for your copy of the new complete Sorensen catalog, S-L. It is filled with schematic drawings, performance curves, photos, and contains in detail, "Principles of Operations."*



SORENSEN & COMPANY, INC.
STAMFORD, CONNECTICUT

A LINE OF STANDARD REGULATORS FOR LOAD RANGES UP TO 30 KVA.
SPECIAL UNITS DESIGNED TO FIT YOUR UNUSUAL APPLICATIONS.

diated power in excess of 25 kw. Later, a 50-kw will be installed for 400-kw effective power.

Reports of consistent service have been received from St. Cloud, 60 miles from the transmitter. Rochester, 78 miles and St. Peter, 58 miles, all in Minnesota, and Grantsburg, Wisconsin, 64 miles. Other reports from Little Falls, 80 miles from Minneapolis and Duluth, 130 miles distant, also reported noise-free reception at those distances.

Metallized Capacitor Data

BECAUSE OF the interest shown by radio engineers in the metallized paper capacitors using a vapor-deposited zinc film developed in Germany, James Cornell of Solar Mfg. Corp. delivered a paper at the Rochester Fall Meeting that presented a picture of American developments in this field and supplied data with which design engineers may apply metallized paper capacitors to their circuit requirements.

Solite capacitors, the pioneer metallized paper units made available in this country, are fixed capacitors in which pure aluminum electrodes have been applied to the dielectric by means of a high-vacuum vaporization process. The resultant capacitors are not only considerably reduced in size but are also self-healing.

Standard impregnated paper capacitors consist basically of windings of two 0.00035-inch metallic foils separated by a minimum of two or more plies of Kraft capacitor tissue. The multiple-ply dielectric is employed so that there will be little chance of failure from metallic particles or weak spots in the tissue.

Self-healing

In the Solite capacitors there is no foil. Instead, the capacitor electrodes are 25 to 100 millicron thick metallic coatings deposited on the paper. This thin film has the property of self-healing, permitting the use of a single-sheet dielectric. During the course of processing metallized paper, metal inclusions in the paper and weak spots in the tissue are removed, allowing the single tissue to be worked at its maximum electrical stress. For working volt-

Recommended

LOUDSPEAKER EQUIPMENT

for typical broadcasting stations

ALTEC LANSING

The monitoring speakers you choose today may decide your place in broadcasting circles for the next ten years. Your choice is as important as that! These Altec Lansing speakers, which we recommend for specific locations in your station, will not only keep you ahead of competition today, but prepare you for the technical advancements to come. You can't "do better" than Altec Lansing loudspeaker equipment.

Model 604 Duplex

recommended for: **CONTROL ROOM AND OWNER'S OFFICE**

The people who carry the responsibility for a station's reputation must have a speaker of Duplex caliber for critical listening. This famous two-way multi-cellular Duplex is unequalled by any speaker at any price.

Model 603 Dia-Cone

recommended for: **RECEPTION AND AUDIENCE VIEWING ROOM**

In less critical locations, this 15-inch Dia-Cone provides superior performance at lower-than-planned investment. The multi-cellular construction makes possible wide angle coverage for large audiences.

Model 600 Dia-Cone

for: **AUXILIARY SPEAKER IN MISCELLANEOUS LOCATIONS**

A small scale edition of the Altec Lansing quality you find in more expensive models, both the 600 and 603 incorporate the Dia-Cone principle of driving separate high and low frequency diaphragms from a single 3" voice coil of edgewise wound aluminum ribbon.

See your dealer or write us for further information.

ALTEC

LANSING CORPORATION

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250 W. 57th St., N.Y. 19, N.Y.

CABINETRY: *This distinctive mahogany floor cabinet is ideal for owner's office and reception room. We recommend it for its impressive appearance. Wall and utility cabinets are also available.*

"KEEP ADVANCING WITH ALTEC LANSING"

Will low moisture absorption help solve your problem?

Indicated are typical coil forms used in communication and radio circuits where low moisture absorption is a vital factor. Supplied by FRANKLIN LAMITEX completely punched and threaded.

FRANKLIN LAMITEX and VULCANIZED FIBRE

. . . In Sheets, Rods and Tubes, Fabricated or Molded Parts

Low moisture absorption is only one of many advantages you get when FRANKLIN's LAMITEX is specified for your job. This versatile material is highly machineable, or if you lack the proper facilities we will fabricate the parts for you. Both LAMITEX and FIBRE can be drilled, tapped, turned, threaded, punched, shaved, bored, reamed, sawed, milled or completely fabricated into automatic screw machine parts.

Check these FRANKLIN LAMITEX characteristics

- High dielectric strength
- Low power factor
- Low moisture absorption
- Remarkable dimensional stability
- High mechanical strength
- Low co-efficient of thermal expansion
- Low in weight (about half that of aluminum)
- Unaffected by solvents and oils
- Unaffected by most organic acids, dilute mineral acids or salt solutions

Send for catalog containing complete data.

FRANKLIN FIBRE-LAMITEX CORP.
WILMINGTON, DEL. • 187 LAFAYETTE ST., NEW YORK 13

age ratings above 200, multiple layer or interleaved constructions are used.

The metallized paper capacitor will not break down at its rated working voltage until a weak spot develops in the dielectric. If this happens, the resulting arc discharge through the paper removes the weak spot and vaporizes the aluminum film around the weak spot, clearing the fault. The aluminum is redeposited as aluminum oxide, an excellent insulating material, and the capacitor has healed itself.

In addition to the space-saving feature, the weight of a Solite capacitor is only ⅓ to ¼ of the conventional design when using aluminum foil. Lead foil capacitors, preferred by some manufacturers, are still heavier.

Test Voltage

A breakdown test of two to three times rated working voltage has been considered standard for small capacitors of conventional design but this does not hold for metallized paper units where the test voltage must be restricted to 1.5 times the working voltage. By taking full advantage of the self-healing properties, the working voltage stress has been safely increased since the removal of the incipient faults in the dielectric has made the insulation more reliable. This accounts for the smaller spread between test and working voltage.

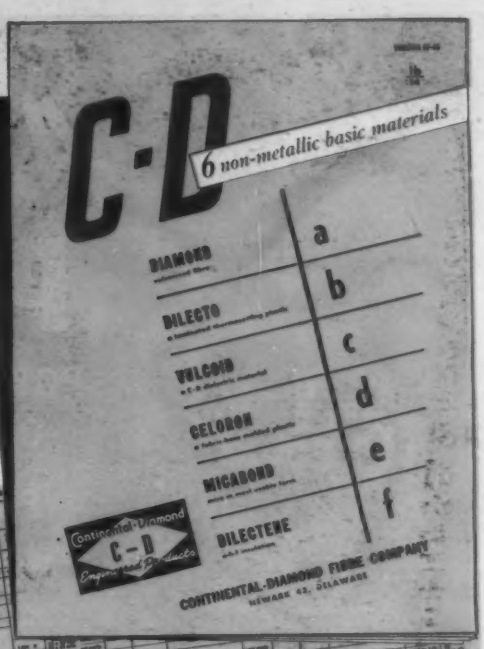
If a direct voltage is applied to a metallized paper capacitor and an oscillograph is used for detecting voltage breakdown, occasional breakdowns of weak spots in the dielectric paper will show as the test potential is increased. In time these incipient faults clear and there is no further indication of spark discharge.

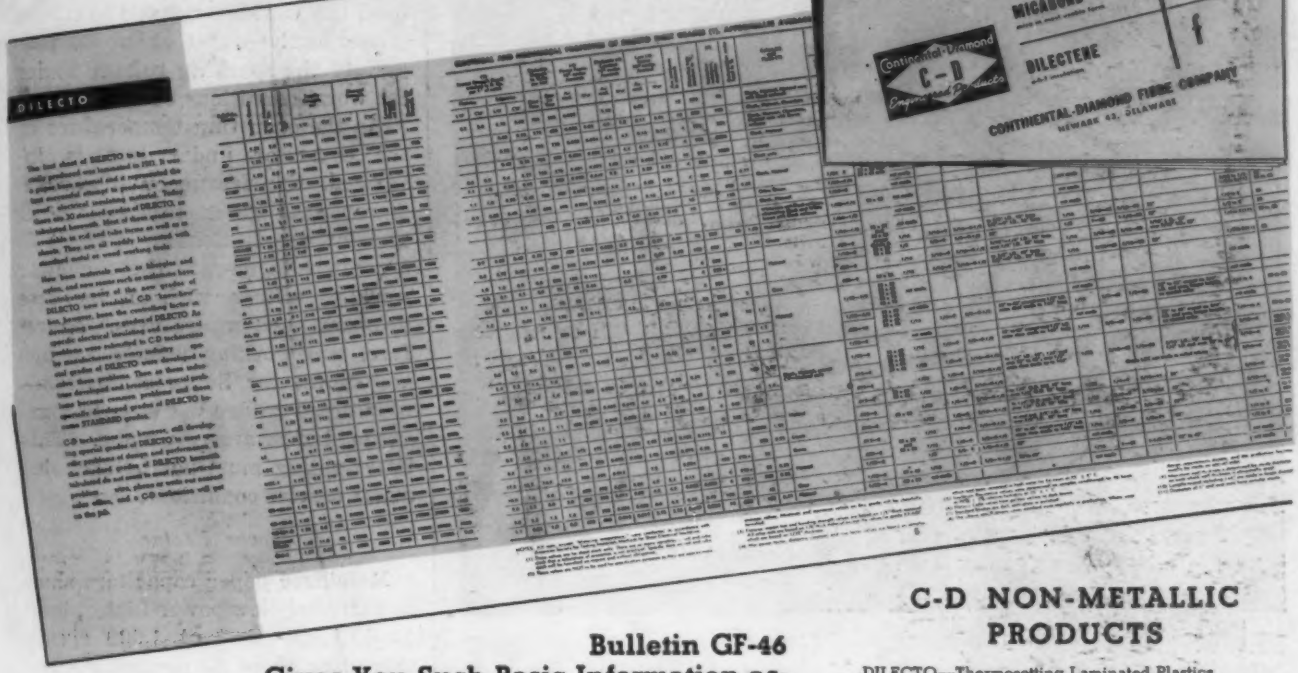
As the test voltage approaches the dielectric strength of the Kraft tissue, the oscilloscope shows a rapid increase in the number of spark discharges. If the capacitor is subjected to a voltage close to its ultimate breakdown voltage or to its sparking voltage (lowest applied voltage which will cause continuous self-healing action), the metallic coating would rapidly deteriorate as minute areas of film would be taken out by each discharge, until

WHAT ARE *Your* QUESTIONS
About Electrical Insulating Materials?

You're building a good product—but want to make it better . . . you want to improve its electrical characteristics . . . improve its overall performance. Among 38 grades of the 6 C-D non-metallics, there is a grade that will do the trick. But, the question is, which one possesses the properties you require.

To give you such information, C-D technicians have put together valuable engineering data in the new GF-46 Bulletin. It tells you all you need to know about how to select and apply non-metallics for most efficient electrical insulating purposes. Send for it today.





Bulletin GF-46
Gives You Such Basic Information as:

- Physical Properties
- Electrical Properties
- Composition of Material
- Recommended Uses
- Grades, Types and Sizes
- Fabrication Information

If your need for help on insulation problems is urgent, phone or wire our nearest office and a C-D technician will be around to see you—quickly.

Continental-Diamond
C-D
Engineered Non-Metallics

D-1-47

C-D NON-METALLIC PRODUCTS

DILECTO—Thermosetting Laminated Plastics.

CELORON—A Molded Phenolic Plastic.

DILECTENE—A Pure Resin Plastic Especially Suited to U-H-F Insulation.

HAVEG—Plastic Chemical Equipment, Pipe, Valves and Fittings.

DIAMOND Vulcanized FIBRE.

VULCOID—Resin Impregnated Vulcanized Fibre.

MICABOND—Built-up Mica Electrical Insulation.

STANDARD & SPECIAL FORMS

Available in Standard Sheets, Rods and Tubes; and Parts Fabricated, Formed or Molded to Specifications.

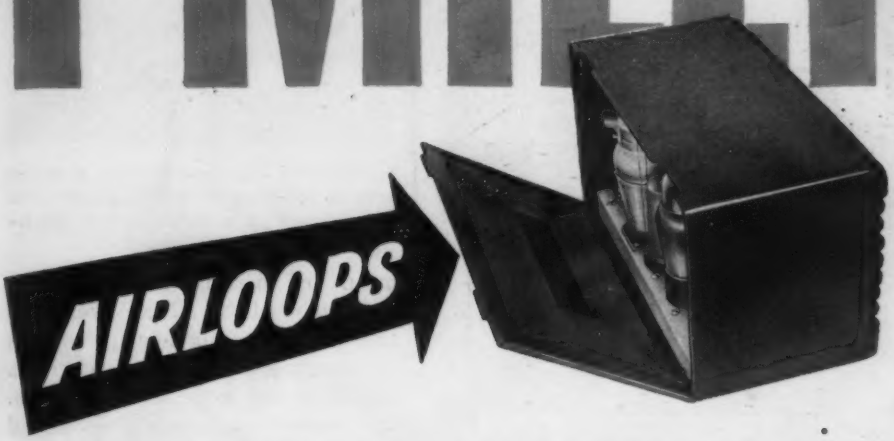
DESCRIPTIVE LITERATURE

Bulletin GF gives Comprehensive Data on all C-D Products. Catalogs are also available.

BRANCH OFFICES: NEW YORK 17 • CLEVELAND 14 • CHICAGO 11 • SPARTANBURG, S. C. • SALES OFFICES IN PRINCIPAL CITIES
WEST COAST REPRESENTATIVES: MARWOOD LTD., SAN FRANCISCO 3 • IN CANADA: DIAMOND STATE FIBRE CO. OF CANADA, LTD., TORONTO 8

Continental Diamond FIBRE COMPANY
Established 1895 . . Manufacturers of Laminated Plastics since 1911—NEWARK 16 • DELAWARE

1 MILLION



INSTALLED IN RADIO RECEIVERS IN LESS THAN A YEAR

*AIRLOOPS . . . *back panel and loop antenna in one unit*

It was less than a year ago that large scale production of **AIRLOOPS** began to feed radio set assembly lines and in this short time more than a million receivers, fitted with **AIRLOOPS,** went into service throughout the world.

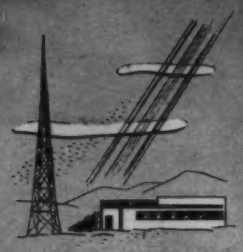
The enthusiastic acclaim and acceptance of the **AIRLOOP** is well earned. It has demonstrated that its many superior features improve set performance and lower the cost of radio assembly and manufacture. Time and use have proved the **AIRLOOP** the most significant post war development in radio components . . . no set builder can afford to overlook the values **AIRLOOPS** contribute to set performance.

FRANKLIN *Airloop*

. . . . . flat sheets of copper die-stamped into perfect super sensitive loops . . . are air dielectric throughout . . . are lower in cost . . . are back panel and loop in one unit . . . have high uniform "Q" over entire band . . . have low distributed capacity . . . have 27% greater effective loop area . . . have electrical and mechanical stability . . . increase set sensitivity . . . eliminate individual loop adjustment . . . eliminate haywire.

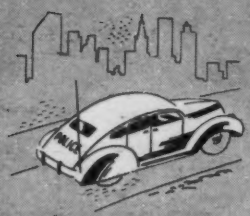
FRANKLIN AIRLOOP CORPORATION

43-20 34th ST. LONG ISLAND CITY 1, N. Y.

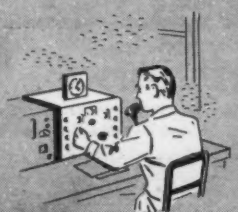

RADIO STATION STANDBY

MOBILE RADIO UNITS

GEOPHYSICAL SURVEY

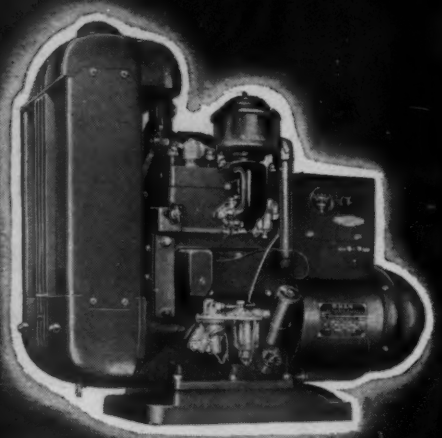

MUNICIPAL SIGNAL STANDBY

RAILROAD RADIO


AMATEUR RADIO

"SPOT" RECORDING

A.C. OR D.C.
POWER
PORTABLE, STANDBY
OR STATIONARY
for
Electronics Uses



Onan Electric Plants are completely self-contained, dependable power units built in a wide range of sizes and standard voltages.

Lightweight, one or two-cylinder, air-cooled models offer the maximum in portability for many applications. Portable A.C. models—350 to 3,000 watts; portable D.C. models—600 to 5,000 watts.

Although widely used for intermittent service as standby units, Onan two, four, and six-cylinder water-cooled plants are built for continuous heavy-duty operation . . . stationary or mobile. A.C. models—3 KW to 35 KW; D. C. models—3.5 KW to 10 KW.

WRITE FOR FOLDER

●

ONAN Electric Plants are available in many sizes and models. ALTERNATING CURRENT: 350 to 35,000 watts in all standard voltages and frequencies. DIRECT CURRENT: 600 to 10,000 watts, 115 and 230 volts. BATTERY CHARGERS: 500 to 3,500 watts; 6, 12, 24 and 32 volts.

D. W. ONAN & SONS INC.

3560 Royalston Ave. Minneapolis 5, Minn.

an appreciable area would be robbed from the winding. If the sparking voltage is applied long enough, the ultimate result would be complete self-destruction of the capacitor.

Working Voltage

By plotting the frequency of breakdowns as a function of the test voltage, it is possible to determine the sparking voltage and to set the rated working voltage at such a value that there will be negligible arcing or spark discharges in actual service. In rating Solite capacitors, the working voltage has been consequently set at about 60 percent of the sparking voltage under the worst conditions of operation.

As the operating temperature of the capacitor under test is increased, the frequency of breakdowns at a given test voltage is also increased. Consequently, it is necessary to de-rate the capacitor working voltage with an increase in operating temperatures. Therefore, two working voltage ratings are shown for Solite capacitors—room temperature w-v d-c and maximum temperature w-v d-c. This latter rating must not be exceeded under service conditions.

Power Factor

Metallized paper capacitors show an extremely low power factor, both at 60 cycles and at 1,000 cycles, averaging about 0.3 percent at room temperature. The low value is due to the combination of a noninductive winding, the short length of section inherent in metallized paper construction, and the use of hydrocarbon waxes or oils as the impregnating medium, coupled with the dry-assembly process of manufacture. The power factor loss attributable to the impregnant itself is the same regardless of whether foil-paper or metallized paper is used.

In making life tests on metallized paper capacitors, protective resistors must be used in series with each test sample in order to limit discharge current. Otherwise, momentary arcing of a single capacitor in a test bank will cause discharge through the fault of the entire stored energy in all other capacitors in the bank. In this respect, the life testing arrangement for metallized paper capacitors resembles that for dry electrolytics.

FIBROUS GLASS TUBING*

IF IT'S TURBO—
IT SAFEGUARDS!

...a special insulator for the really "tough" jobs!

ASK THE DESIGNER! He knows that glass stands near the top of the list of dielectrics which offer greatest resistance to heat, corrosion, flame, oxidation, rot and other deteriorants. Woven of soft, flexible fibrous glass yarn, TURBO Glass Tubing is inherently an excellent insulator. Combined with TURBO varnish impregnants in the manufacturing process, it becomes an ideal material for exceptionally difficult applications. Below are listed some of the other quality TURBO insulating materials extensively used in industry:

Saturated Sleeving	An all purpose insulation for any but the higher dielectric ranges. Varnish impregnated cotton yarns. Flexible, strong, resistant to acids and oils. Good moisture and flame resistance. Dielectric breakdown—1200 V., per ASTM test.
Plastic Insulated Wire	Number 18 and finer stranded and solid conductor with a seamless extruded plastic insulation. Surpassing dielectric properties. Resistant to oils, organic solvents, acids, alkalies and oxidation. Minimum shrinkage and burning effects in soldering and potting.
Varnished Tubing	A superior braided cotton insulation featuring saturation impregnation of flexible varnishes. Strong, flexible, non-peeling, non-cracking, moisture, oil, acid and flame resistant. Dielectric breakdown ASTM test—Magneto grade—7000 V., Radio grade—4000 V.
Mica & Mica Products	All forms—plate, block segments, films. Rigid control in all stages—grading selection, fabrication and testing insures uniformity and quality in finished products. Meets all tests involving physical and electrical stability. Specific problem-collaboration is invited.

TURBO

WILLIAM BRAND & COMPANY
276 FOURTH AVE., NEW YORK 10, N. Y. - 325 W. HURON ST., CHICAGO 10, ILL.

When something is needed "yesterday" Specify Air Express delivery

Here's the fastest solution to the problem of supplies and parts that are "fresh out" — get them by Air Express. This super-speedy service places even the most distant supplier only hours from your business.

Speeds up to five miles a minute now make coast-to-coast and overseas deliveries a routine affair for Air Express. And now it's a better value than ever before. The cost of shipping by speedy Air Express is *low*.

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Just phone your local Air Express Division, Railway Express Agency, for fast shipping action . . . Write today for Air Express Rate Schedules containing helpful shipping aids. Address Air Express, 230 Park Avenue, New York 17. Or ask for them at any Airline or Railway Express Office. Air Express Division, Railway Express Agency, representing the Airlines of the United States.

AIR EXPRESS

AIR EXPRESS

GETS THERE FIRST

Rates are low

To Air Express a 10-lb. package 1549 miles costs only **$4.65!** Heavier weights are similarly inexpensive. Investigate!

INDUSTRIAL CONTROL

(continued from p 142)

By applying adhesive through a stencil prior to electrostatic treatment, a tufted material having a design such as shown above is formed

means of which "Dotted Swiss" and embroidery effects were obtained. In making such decorated textiles, adhesive is applied with a stencil in the pattern desired, and the fibers are electrostatically pulled into the adhesive. The decorated material is then cured and the process is complete. The decorated fabrics are able to withstand repeated laundering and drycleaning. The process is a development of Behr Manning Corp. of Troy, N. Y.

A pile fabric that feels like velvet has also been developed. This has a backing of cloth, paper, or any other material put up in continuous sheet or web form, such as cellophane, plastics, etc. To this backing a dense, even pile of fibers is adhesively anchored. Methods have been devised for patterning and embossing this material, and many effects have been obtained which cannot be duplicated by conventional textile weaving machinery.

Densities of 300,000 erect fibers per inch are obtained and standard wear tests show ratios of three to one in favor of electrostatically flocked materials.

Fluorescent Lamp Delay Timer

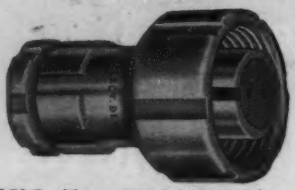
COMMERCIAL fluorescent lamp sizes as well as the standard germicidal lamps can be measured for starting lag with the circuit shown in the accompanying diagram.

First the input voltage is ad-

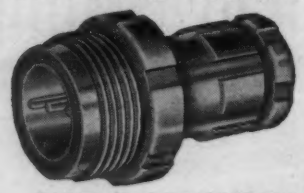
NEW ELECTRIC CONNECTORS BY CANNON ELECTRIC

TYPE "W" WATERPROOF CONNECTORS

Type "W" Plugs coupled and standby Waterproof Caps on buoy used in offshore, undersea geophysical exploration by United Geophysical Company.



PLUG—Type W16-11S-21-1/4
Two #12 Wires—socket insert

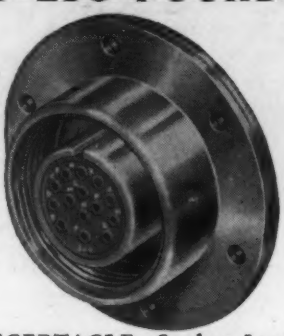


PLUG—Type W16-11P-22-1/4
Two #12 Wires—pin insert

This new "W" Series of heavy-duty, multi-contact connectors is designed for uses undersea, underground and where moisture or spray conditions require thoroughly sealed fittings. Available in three shell sizes based on "AN" insert sizes Nos. 16, 22 and 36, with nearly 50 insert-contact arrangements to pick from in the "AN" Series.

PRESSURE-TESTED TO 250 POUNDS

RECEPTACLE—Pin Insert assembly, showing special rubber sealing ring and Acme Thread. Shell material brass, nickel plated.



RECEPTACLE—Socket Insert Assembly, with double flange construction. Insert No. 22-19 shown with 14 #16 contacts.

For additional information, write Dept. C-120 for Bulletin W-126. Please specify "AN" Bulletin for insert information, if desired. Prices quoted on complete assemblies only from factory or Cannon Engineering Representatives located in principal U. S. A. cities.

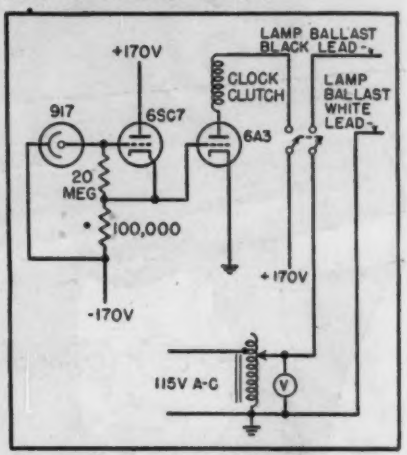
CANNON ELECTRIC

CANNON ELECTRIC DEVELOPMENT COMPANY

3209 Humboldt Street, Los Angeles 31, California

Canada & British Empire—Cannon Electric Co., Ltd., Toronto, Ontario • World Export Agents (excepting British Empire) Frazar & Hansen, 301 Clay St., San Francisco 11, Calif.

justed to suit requirements of lamp under test. Then the switch is closed, energizing the clock clutch coil and the lamp ballast. When the test lamp does not light, no current will flow from the 917 photocell through the grid resistor of the 6SC7 cathode follower. Consequently, the cathode follower draws a maximum of plate current, and the 6A3 triode is thus made positive. Low plate to cathode resistance of the 6A3 permits operation of the clock clutch.



Circuit of phototube relay for time lag measurement

When the test lamp lights, current through the 917 photocell causes the grid of the 6SC7 to become negative, reducing the plate current. Since the 100,000-ohm cathode resistor will then have less voltage drop, the 6SC7 cathode becomes negative with respect to ground. The grid of the 6A3 connected to this cathode will be cut off and clock clutch will drop.

The operating current of the clock clutch coil ranges from 40 to 50 milliamperes and is easily handled by the 6A3 tube. Use of the cathode-follower circuit permits the use of high series resistance in the phototube circuit for high sensitivity and convenient cable length between the phototube and the 6A3. The circuit is suggested by Trevor Temple of Sylvania Electric Products. The phototube selected should be sensitive to radiation characteristic of lamp being tested. The cathode follower may be any high mu, low plate current triode. The output tube should be capable of supplying relatively large plate current at nominal plate voltages. A large input resistor to the cathode follower

FOR POWER CONVERSION AC to DC

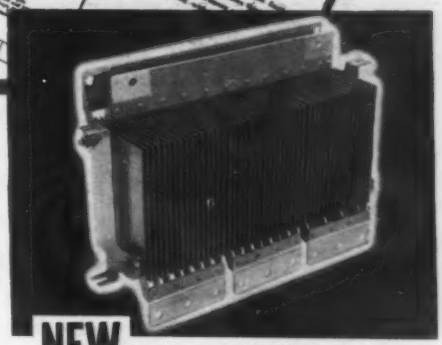
Specify Federal's Standard Rectifier Equipments

Federal
STANDARD SELENIUM RECTIFIER EQUIPMENTS
WRITE FOR BOOKLET—This 12-page illustrated booklet gives electrical data and prices on Federal's complete line of standard Selenium Rectifier Equipments. Whatever your D-C needs, you'll find a Federal rectifier that's designed for the job. This booklet is yours for the asking. Write for your copy of Bulletin E713.
Electroplating Equipments
Industrial Truck Battery Chargers
General Purpose Battery Chargers
Cathodic Protection Equipments
Industrial Power Supplies
Central Station Battery Chargers
Telephone Battery Chargers
Power Supplies

WHEN YOU NEED D-C from an A-C source, consider the time - and money-saving advantages of Federal Selenium Rectifiers. They operate *silently*, without tubes or moving parts which require frequent replacement. They're ruggedly constructed to withstand shock and vibration. Service life is practically unlimited, with almost no attention or maintenance. And they run *cooler*, too —start *instantly* when the power is turned on.

The Selenium Rectifier is an IT&T development, pioneered and perfected in this country by Federal. And Federal rectifiers have given years of outstanding service with all types of equipment in all branches of industry — every unit backed by many years of experience in design and manufacture.

Made by America's Largest and Oldest Manufacturer of Selenium Rectifiers!



NEW 48-plate Federal Selenium Rectifier provides more power output in less space than any previous unit of its type.

Federal Telephone and Radio Corporation

In Canada:—Federal Electric Manufacturing Company, Ltd. Montreal.
Export Distributors:—International Standard Electric Corp. 67 Broad St., N. Y. C.

An IT&T Associate

Newark 1, New Jersey

THE BALLANTINE
ELECTRONIC
AC VOLTMETER

100 Times more Sensitive than Conventional Models

since 1935 the only VOLTMETER featuring a simplified LOGARITHMIC SCALE

Model 300 Sensitive Electronic Voltmeter—a valuable laboratory or production line instrument—highly accurate—stable calibration—capable of reading down to 1 millivolt and up to 100 volts over a wide frequency range with an overall accuracy of 2%. Single logarithmic scale makes readings especially easy. Unaffected by changes in line voltage or by tube replacement. Can be used as a high gain (70 DB) amplifier — frequency range flat from 10 to 150,000 cycles.

Send for Bulletin 10

BALLANTINE LABORATORIES, INC.

BOONTON, NEW JERSEY, U. S. A.

may be used, particularly if available radiation is small. The value of the cathode resistor is not critical, but it should not exceed 0.5 megohm. Adjustment of clock clutches may be required, since, as they are supplied, there is a wide range in the values of pull-in current.

First Factory F-M Radiophone

FIRST INDUSTRIAL plant authorized by the FCC to use two-way radiophone is that of the Haskell and Barker freight car plant of Pullman-Standard Car Manufacturing Company. The installation consists of a Motorola central station and six mobile sets. Four receiver-transmitters are located in 45-ton diesel switch engines, while two more have been installed in locomotive cranes, used to unload materials at production lines or to perform routine maintenance. The central control station is housed in a special sound-proof room in the scale house of the plant.

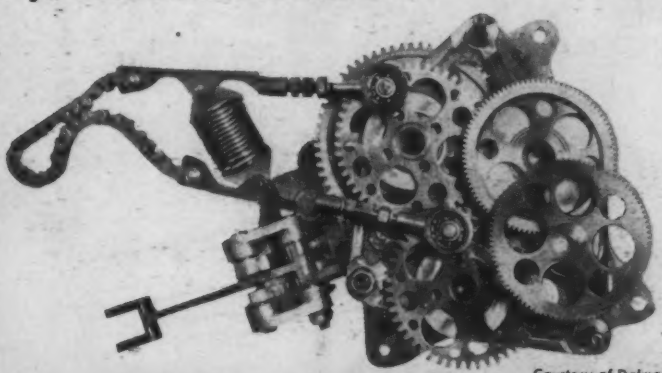
The switch engines and cranes are used on more than 22 miles of criss-crossed track that traverse the 80-odd acres occupied by the big Haskell & Barker plant. In the past, where and when this equipment would be needed and used made work schedules a difficult problem. When emergencies arose, it took the yardmaster an hour or more to locate an engine or crane and get it where it was needed, wasting many man hours on the

Manufacture of freight cars is speeded up by Motorola two-way f-m radio equipment at Pullman-Standard Car. Yard cranes and locomotives used to unload materials at production lines are controlled from a central station

36 TRUARC rings reduce weight, eliminate parts in complex radar aircraft antenna!

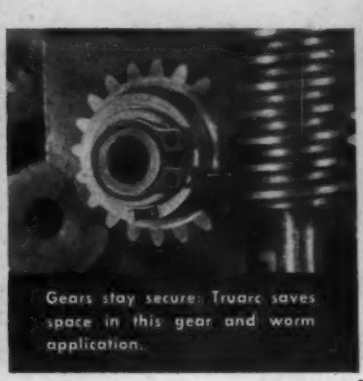
● Waldes Truarc Retaining Rings cut machining, assembly, maintenance time

Tiny rings easily installed keep link pins in position, are easily removed for maintenance.



Courtesy of Dalmo-Victor

Truarc snaps in place easily as a ball-bearing retainer, allows use of shorter bushing.



Gears stay secure: Truarc saves space in this gear and worm application.

Assembly in cramped space with practically no clearance is simplified with Truarc ring.

"TRUARC NOT ONLY REDUCES WEIGHT IN OUR APS-4 AIRCRAFT ANTENNA," states Dalmo-Victor, of San Carlos, California, "but also saves numerous machining, drilling and threading operations and reduces assembly and maintenance time. Waldes Truarc Retaining Rings are easy to install and remove, give equal pressure over a continuous surface because of their perfect circularity, and eliminate large numbers of tools hitherto required. They do not deteriorate under the most rigorous operating conditions."

Wherever permanent maintenance of tolerance is important, Truarc rings keep moving parts in accurate relationship. In all industries, designers find Truarc a better way of fastening machine parts; production and maintenance men find Truarc cuts costs. Send us your drawings; Waldes Truarc engineers will be glad to show how Truarc can help you.

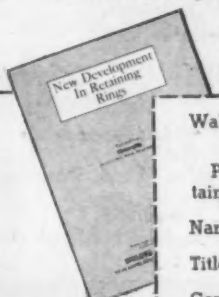
WALDES

TRUARC

U. S. PATENT RE 22,144 AND OTHER PATS. PEND.

RETAINING RINGS

WALDES KOHINOOR, INC., Long Island City 1, New York



● *Send for New Truarc booklet, "New Development In Retaining Rings"*

Waldes Kohinoor, Inc., 47-10 Austel Place 18-L
Long Island City 1, N. Y.

Please send booklet, "New Development In Retaining Rings" to:

Name_____

Title_____

Company_____

Business Address_____

City_____ Zone____ State_____

PRODUCING A LOT OF
NOTHING

Compact installation of Kinney Compound High Vacuum Pumps used to back diffusion pumps in the manufacture of ultra high frequency tubes at Raytheon Mfg. Co., Waltham, Mass.

IN A SMALL SPACE

The compact design of Kinney High Vacuum Pumps enables them to be grouped closely with auxiliary equipment . . . shortens pipe lines . . . saves valuable floor space. Kinney Pumps are self-contained units, easily installed. Having automatic lubrication and oil sealing, they produce high vacuums indefinitely with minimum attention.

The faster pump down and lower ultimate pressures of Kinney High Vacuum Pumps shorten production time and cut costs in vacuum processing—exhausting lamps and tubes, sintering alloy metals, coating lenses, producing drugs, etc. Kinney Single Stage Vacuum Pumps produce low absolute pressures to 10 microns; Compound Pumps to 0.5 micron.

Write for Bulletin V-45.

KINNEY MANUFACTURING COMPANY
3565 Washington Street Boston 30, Mass.
New York • Chicago • Philadelphia • Los Angeles • San Francisco
FOREIGN REPRESENTATIVES
General Engineering Co. (Radcliffe) Ltd., Station Works, Bury Road, Radcliffe, Lancashire, England
Horrocks, Roxburgh Pty., Ltd., Melbourne, C. I. Australia
W. S. Thomas & Taylor Pty., Ltd., Johannesburg, Union of South Africa

KINNEY HIGH VACUUM PUMPS

production line. With radio equipment, the yardmaster keeps track of every locomotive and crane and directs it in a matter of seconds.

The equipment is frequency modulated and operates in the new 152-162-megacycle band. Solid ground-wave coverage within the operating area of the plant is expected. The diesel locomotive installations use a generator connected directly to the engine, which operates a standard battery system, supplying power for the radio. Steam cranes have a six-volt gasoline driven generator supplying the power.

Ultrasonics, A New Tool

THE EARLIEST study of ultrasonic vibrations is credited to the German, Koenig, who produced tuning forks in 1876 capable of 90,000 vibrations per second. The Galton whistle developed by Edelmann produced 100,000 vibrations per second by means of air forced into a cylinder with a movable piston.

Magnetostriction was discovered by Joule when he found that a magnetized bar, brought into a magnetic field, changed in length and, if the changes were rapid, the bar would emit waves of high frequencies.

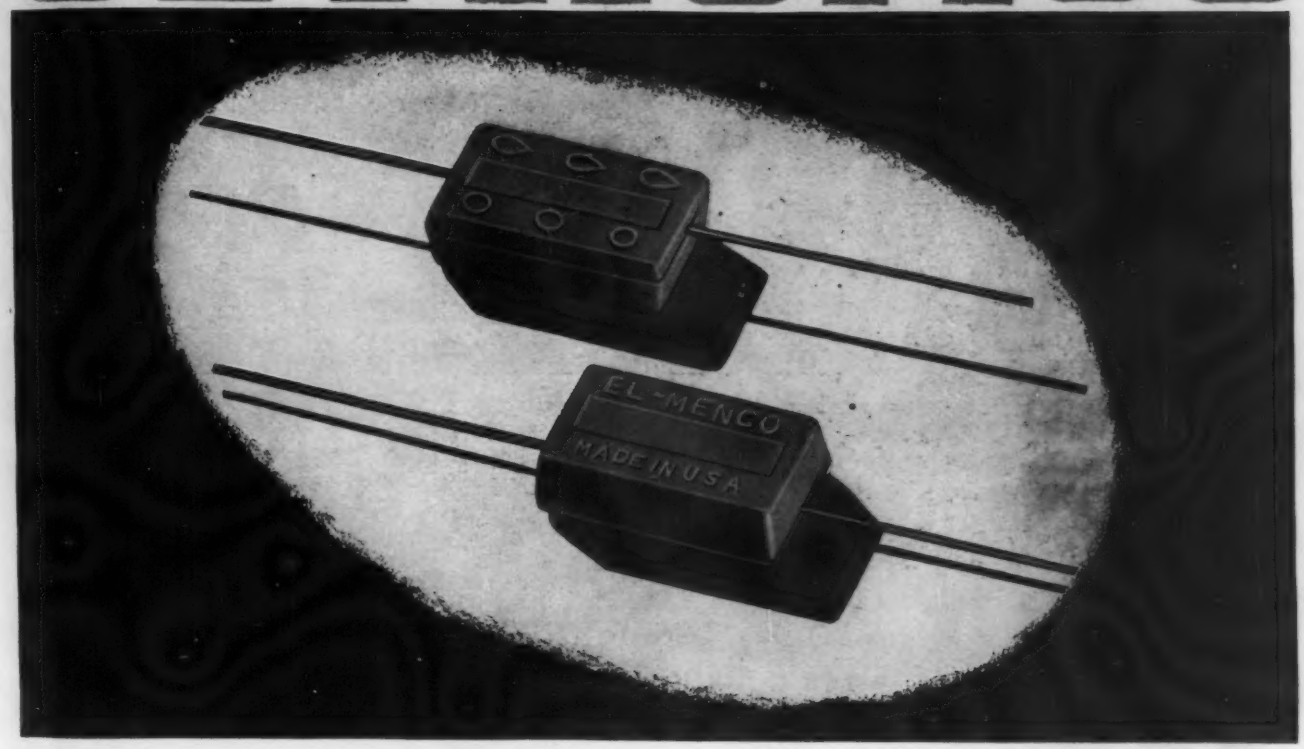
Chief difficulty in the study of these high-frequency waves was the problem of a suitable generator. Before World War II, ultrasonic generators were available to German manufacturers but these were very expensive, difficult to obtain, and were unsuited for general use. One of the first practical ultrasonic generators available was perfected by Langevin, who developed the submarine detector. The piezoelectric method originated with the Curie brothers in 1880.

A wide-spread inquiry into the principles of ultrasonics has been undertaken by many laboratories and a considerable amount of observed ultrasonic phenomena has indicated a large variety of industrial and other applications. Many industrial laboratories are unaware of what others in the same fields of research are achieving and to help disseminate useful information, some of the phenomena reported by Televiso Products Company are given below.

Immiscible liquids, such as water

EL-MENCO

GOOD PRODUCTS BUILD GOOD NAMES



Because the makers of EL-MENCO Capacitors have always insisted on quality at any cost, the name EL-MENCO is now recognized as the identification mark of leadership.

EL-MENCO Capacitors—Molded Mica—Mica Trimmer. We are bending every effort to satisfy all manufacturers who want these quality products. Send us your specifications and we will do our level best to supply you.

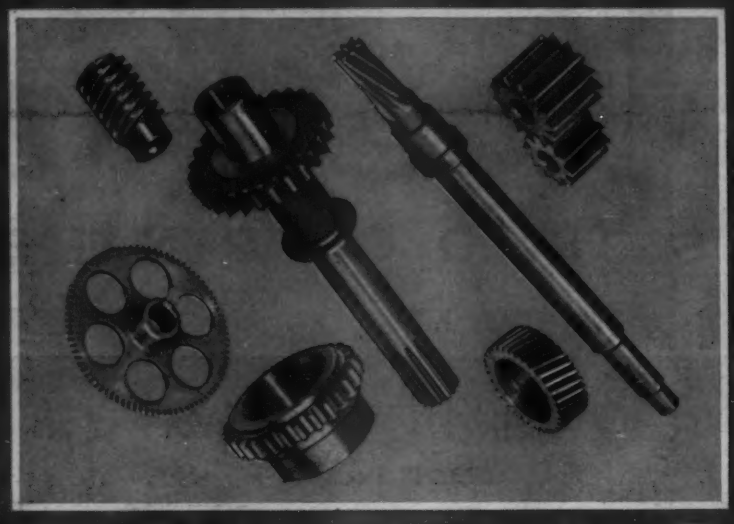
THE ELECTRO MOTIVE MFG. CO., Inc. Willimantic, Conn.

Our new catalogue for manufacturers and engineers is now available . . . send for your copy

MOLDED MICA **EL-MENCO CAPACITORS** MICA TRIMMER

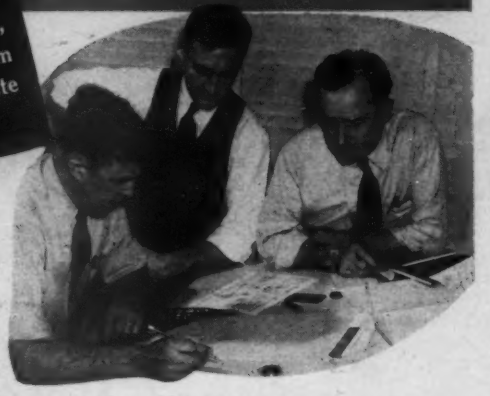
Foreign Radio and Electronic Manufacturers communicate direct with our Export Department at Willimantic, Conn. for information.

SMALL AND MEDIUM SIZE . . .



GEARS

Spurs, Helicals, Straight Bevels, Sprockets, Racks, Worms, Worm Gears, Thread Grinding, Complete Gear Trains.



Beaver engineers at work. These men will design or redesign a gear to meet performance and cost specifications.

Precision-made gears in standard and special tooth forms, from any kind of material, made to meet your requirements. Gears for electrical devices, instruments, apparatus, and other mechanical movements. Precision grinding of worms and threads. Highly specialized production methods and inspection equipment insure gears made to exact specifications. Send us your blueprints for estimate.

Write Today for this FREE BULLETIN

Complete information on Beaver Gear facilities and methods . . . views of various operations, and illustrations of gears produced to the exact specifications of various customers.

Beaver Gear Works Inc.

1021 PARMELE STREET, ROCKFORD, ILLINOIS

and oil, or water and mercury, can be transformed into stable emulsions by treatment with intense ultrasonic waves. Experiments reveal that absorbed gases have a stabilizing effect in water-mercury emulsions thus produced. At frequencies between 300 and 400 kilocycles, very fine emulsions of mercury, tin, sulphur, copper, lead, bismuth, silver, and paraffins can be produced in water.

Fine Grain Film

The action of ultrasonics on photographic emulsions improves the stability and increases the resolving power and sensibility of the film. The injurious grouping of grains in the photographic emulsion is not only prevented by ultrasonics, but when present is even abolished. Thus, this application may result in finer-grain film as well as in increasing the speed of present-day film.

Considerable promise lies in the application of ultrasonics to the manufacture of catalytic agents. Several effects have been observed in the ultrasonic dispersions of metals in liquids. If a cathode is subjected to ultrasonic waves during electrolysis, the deposited metal is flung out into the liquid in a dispersed form at high speed. Practically all metals which can be separated by electrolysis can be dispersed in this way and the degree of dispersion can be controlled by the power of the ultrasonic waves, the electrode material, and the cathode surface.

Oxidation

Chemical effects of ultrasonics may be accompanied by a slight heating effect yet reactions are produced which cannot be duplicated by heat. Strong oxidation reactions, for example, are produced by ultrasonics in an aqueous solution of carbon tetrachloride in the presence of potassium iodide and starch. The blue color of the starch appears immediately. Unstable substances such as nitrogen tri-iodide (NI_3) will explode when subjected to the ultrasonic waves.

Highly polymerized molecules can be split up at around 700 kilocycles. Starch can be transformed into dextrine, and substances like gelatin and gum can be decomposed. It is possible that ultrasonics can

A new Electrical Tape that is simplifying the manufacture and maintenance of Electrical Equipment

SCOTCH *Electrical* TAPE

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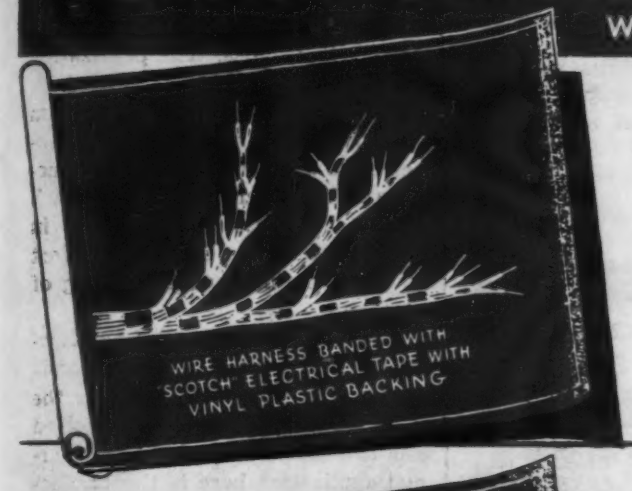
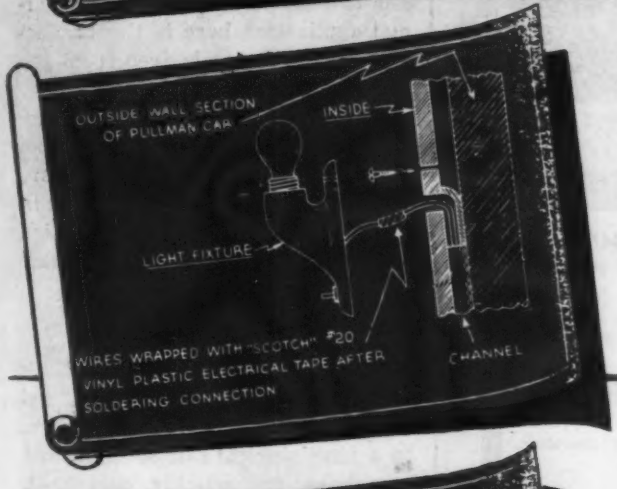


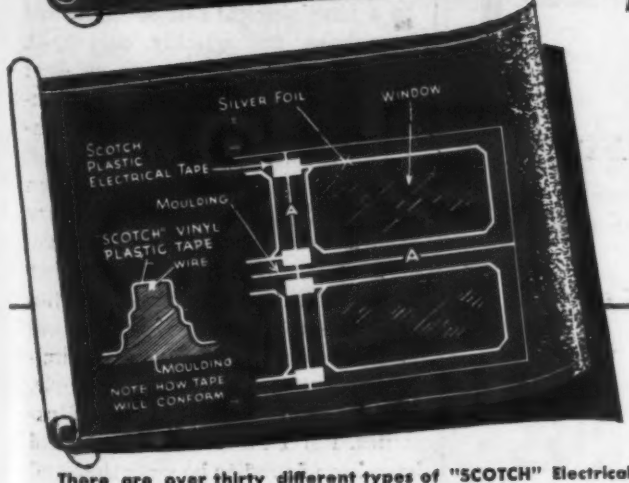
A FAMOUS MAKER OF CONTROL INSTRUMENTS

uses "SCOTCH" Electrical Tape with Vinyl Plastic Backing in place of string lacing to fasten wire harnesses. They band the harness every two inches with the tape, also at each place where a lead comes off. The new method saves time, makes a neater job, produces a more flexible cable.


OUTSIDE WALL SECTION OF PULLMAN CAR
INSIDE
LIGHT FIXTURE
WIRES WRAPPED WITH "SCOTCH" #20 VINYL PLASTIC ELECTRICAL TAPE AFTER SOLDERING CONNECTION
CHANNEL

A GREAT RAILROAD SYSTEM

uses "SCOTCH" Electrical Tape with Vinyl Plastic Backing in equipment maintenance. It takes the place of the rubber and friction tape combination in "over-stuffed" junction boxes. Another use is splicing wire to lighting fixtures to permit splice to fit easily into wire channel, replacing bulkier tapes.



A MANUFACTURER OF BURGLAR ALARMS

facilitates construction, minimizes upkeep and promotes uninterrupted efficiency of his equipment by using "SCOTCH" Electrical Tape with Vinyl Plastic Backing to protect soldered joints on windows, replacing a tape that absorbed moisture and had a tendency to dry up and fall off, particularly after the window was washed.

There are over thirty different types of "SCOTCH" Electrical Tapes, with backings and adhesives to cover an extremely wide range of electrical construction and repair requirements. Write for complete information. If you wish, a "SCOTCH" Tape engineer will call.

"SCOTCH" is the registered trade-mark for the adhesive tapes made in U. S. A. by

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FREQUENCY SHIFT TELEGRAPH

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- New MARK-SPACE rejection circuits are utilized.

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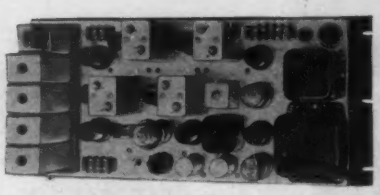
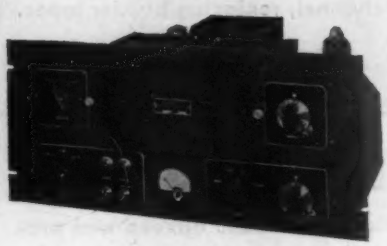
- 20 DB signal to noise ratio at 1 microvolt input.
- Adaptable for dual or triple diversity operation.



TYPE 177-T EXCITER

FOR KEYING TRANSMITTERS BY FREQUENCY SHIFT METHOD



- Fully crystal controlled, provisions for 3 frequencies.
- MARK and SPACE frequencies both adjustable.
- Simplified and dependable operation.

Easily adapted to existing equipment.

Provides an effective 15 to 20 DB increase in circuit signal to noise ratio.

Allows use of lower powered transmitters on radio telegraph circuits.

Extends hours of operation on existing circuits due to greatly improved signal to noise ratio.

Makes automatic printer operation feasible.

ERCO RADIO LABORATORIES INC

GARDEN CITY, NEW YORK

be employed in the refining of petroleum to accomplish the same results now obtained by cracking. On tests using paraformaldehyde, a breaking-up action takes place.

Melts, Gels

The effect of ultrasonics on gels is of considerable value. Iron hydroxides can be liquefied by ultrasonic treatment, but no permanent change takes place in the gel. Apparently, the liquefaction of gels is caused by the creation of cavities and their collapse. The peptization of a gel in liquid is accelerated.

Melts such as tin and aluminum solidify more rapidly when subjected to ultrasonics, and the structure has a finer grain after such treatment. Considerable work in this field has been done in an effort to speed the nitrogen hardening of steel.

Liquids can be degassed by ultrasonics because the liquid expands under treatment, thus reducing the pressure and allowing the dissolved gas to emerge. A possible commercial application here is the production of fused metals free from gas inclusion.

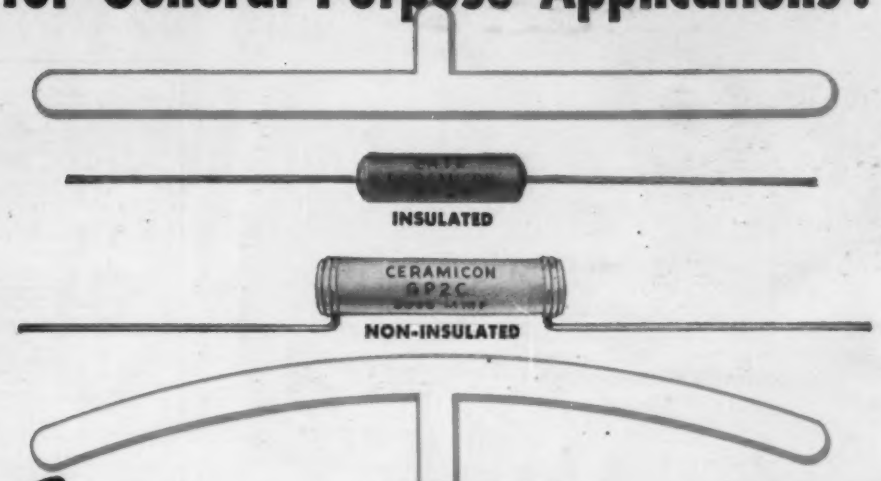
A coagulative effect has been noticed on aerosols. Since substances such as dust, smoke, mist, etc., are merely dispersed solids or liquids in a finely divided state in a gas, this application of ultrasonics may achieve the smokeless city.

Organic Matter

Reminiscent of so-called death rays, small fish and frogs are killed instantly by supersonic exposure. In a physiological salt solution, red corpuscles are quickly destroyed. Effects on bacteria are inconsistent to date—in some cases a diminution in virulence occurs and in others an increase is observed.

Experiments in the sterilization of canned foods, liquids, and dry cereals have achieved complete results in many instances. Another food application of ultrasonics lies in its use as a homogenizing process in the production of milk and similar products. Paint, for example, can be homogenized with ultrasonics. Paint mixtures thus treated have been found to be smoother and to last longer than those not treated. Drying qualities are also improved.

Have You Tried Ceramic Condensers for General Purpose Applications?



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Many leading radio manufacturers have already switched to ERIE "GP" Ceramicons for general purpose applications. These ceramic condensers have all the well-known dependability of other ERIE Ceramicons with their sturdy compactness and ease of installation, *plus* an unprecedented economy for general purpose applications.

ERIE "GP" Ceramicons are designed for practically all applications in which the condenser is not directly frequency determining; for AVC Filtering, Resistance-Capacitance Audio Coupling, Tone Compensation, Volume Control R.F. By-Passing, Audio Plate R.F. By-Passing, Oscillator Grid Coupling, R. F. Coupling, Antenna Coupling.

The production of large quantities at one time of a given capacity value accounts for their economical price . . . *there is no sacrifice in quality.*

Condensers classified as GP1 have a temperature coefficient between +130 and -1600 P/M/°C and are available up through 150 MMF. Condensers classified as GP2, manufactured in capacities of 120 MMF and higher, may include all of the above dielectrics and, in addition, the ERIE Hi-K type.

ERIE "GP" Ceramicons are made in insulated styles in popular capacity values up to 5,000 MMF, and in non-insulated styles up to 10,000 MMF. Write for full details.

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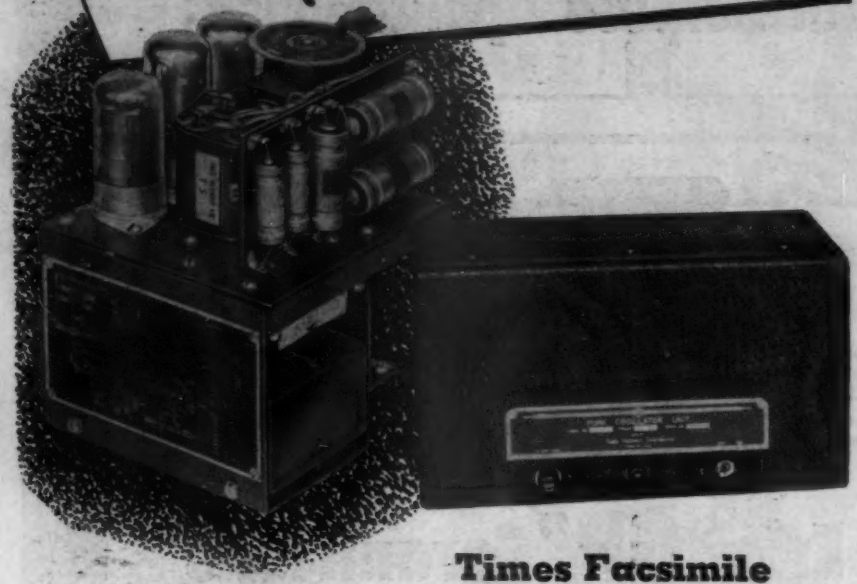

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ELECTRON ART

(continued from p 146)

Fig. 2B. Type A, represented in Fig. 2A by the FG178A, has a circular-plate anode with the cathode some distance away on the axis of the anode so that the magnetic field can be concentrated at the cathode. The spectrum of this type structure has high low-frequency noise, with no peak and a steady decrease in

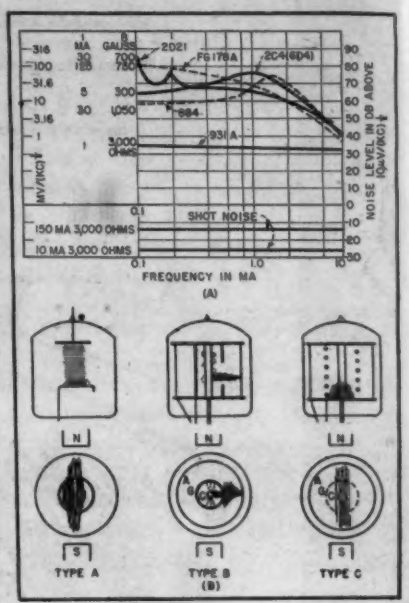

FIG. 2—Characteristic noise from several types of gas tubes

level as the frequency increases. The Type B tube, represented in Fig. 2A by the 884 and the 2C4(6D4), has closer spacing and the cathode is surrounded by the anode structure so that both anode and cathode are in a strong magnetic field. The grid is a solid sheet of metal completely surrounding the cathode except for a small slit which defines the current beam. The spectrum obtained with this structure shows a maximum in the vicinity of one mc. Type C, not represented in Fig. 2A, is similar to Type B except that the grid is an open wire structure. With this type tube (Dumont 6Q5G) it was not possible to eliminate the oscillations for any orientation of the magnetic field. Similar difficulties with the oscillations were found with the 2050 and 2D21 gas tetrodes.

The characteristics of the various types of tubes studied with transverse magnetic field are summarized in Table II. Representative values are given. For most types there is wide variation between

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THE WELL BALANCED DESIGN of conductors and dielectric in Anaconda Type ATV lead-in lines fulfills the exacting requirements of wide-band reception. For FM and television reception, these lead-in lines minimize the effects of attenuation and impedance mismatch—providing maximum freedom from distortion.

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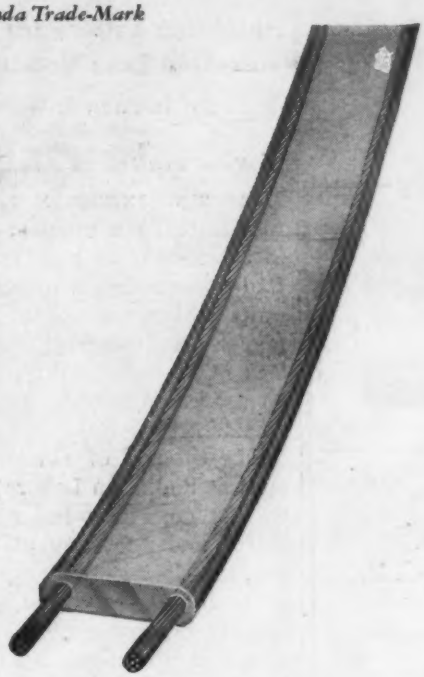

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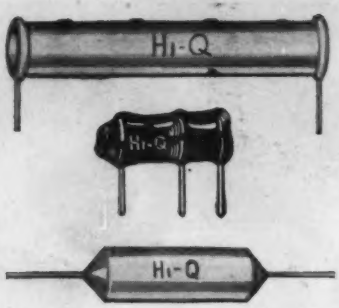

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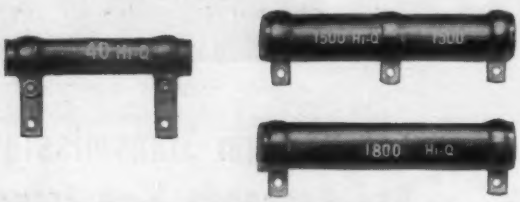
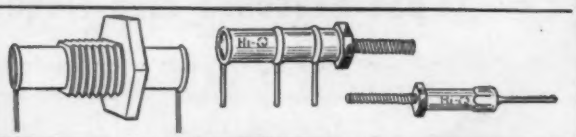


FEED-THRU & STAND-OFF CAPACITORS



CHOKE COILS

HI-Q ELECTRICAL REACTANCE CORPORATION
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tubes. Great uniformity was found in the 6D4 tube, with maximum deviations between tubes of the order of one db or less.

(Work reported in this paper was done in whole or in part under Contract No. OEMsr-411 between the President and Fellows of Harvard College and the Office of Scientific Research and Development.)

Negative Impedance

A THERMISTOR is made to develop an impedance having a negative resistance and an inductive reactance. A shunt containing positive resistance and capacitive reactance is proportioned to neutralize the inductance of the thermistor, leaving just negative resistance at the operating frequency. Bias for the thermistor is supplied from a circuit having a battery, variable resistance and reactance, the reactance giving the bias circuit a high impedance so that it does not load the negative impedance portion of the circuit appreciably (U. S. Patent 2,410,076 granted October 29, 1946 to Kenneth S. Johnson, assignor to Bell Telephone Labs.).

Shielding Filters for Insertion Loss Measurement

By GERSHON J. WHEELER
Radio Engineer
Boston, Mass.
Naval Research Lab. Field Station

MEASURING INSERTION LOSS of filters is really a problem in shielding, especially at high frequencies. Radio-frequency coupling between units of the measuring equipment may cause incorrect results and lack of reproductibility, which can be prevented only by an unbroken shield.

The method of shielding developed at Radiation Laboratory, MIT will be described, but first, for a better understanding of the problem, the electrical arrangement will be outlined. A typical set-up for making insertion loss measurements is shown in Fig. 1. Pad No. 1 terminates the generator output in its proper impedance and the filter input in twenty ohms. Pad No. 2 terminates the filter output in twenty ohms and isolates the receiver. (Twenty ohms on each

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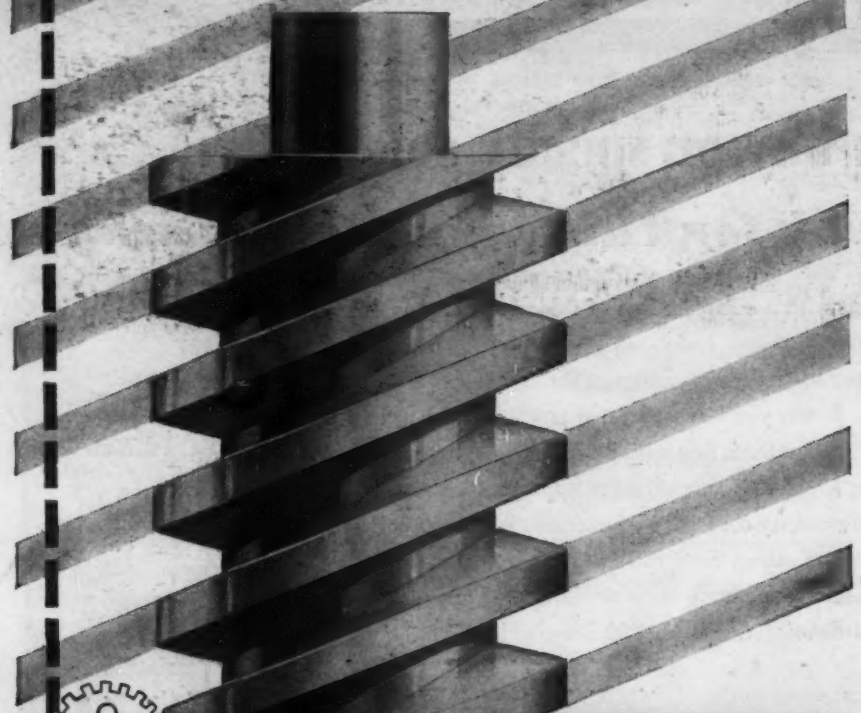

QUAKER CITY GEAR WORKS, INC.
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side of the filter is an arbitrary value which is used extensively.) Measurements are made with the filter in and out of the circuit, adjusting the attenuator so that the

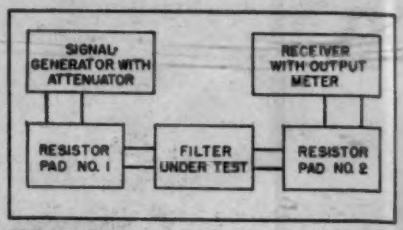

FIG. 1—Basic method of measuring insertion loss of filters is to determine generator output necessary to give same reading of output meter at receiver with and without filter in circuit. Unless complete shielding is used results are not reliable

receiver output is the same for both conditions. The ratio of the signal generator output voltages, expressed in decibels, is the insertion loss of the filter.

Filter Shielding

The filter is mounted on a brass plate, either by soldering or by mounting lugs, in such a manner that the input and output bushings are on opposite sides of the plate. This plate is placed in a copper box which it divides into two completely shielded compartments as illustrated in Fig. 2. Good electrical contact between the plate and the box itself is accomplished by means

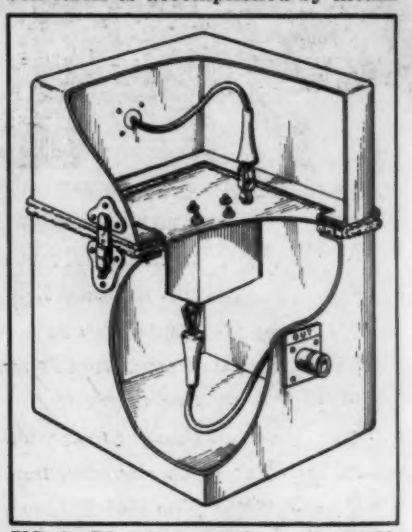

FIG. 2—Filter is mounted on plate inside shield box

of special resilient woven metal gaskets (manufactured by the Metal Textile Corporation). Connections to the filter are made by clip leads. These leads are clipped to each other when the filter is out.

The resistance pads may be built

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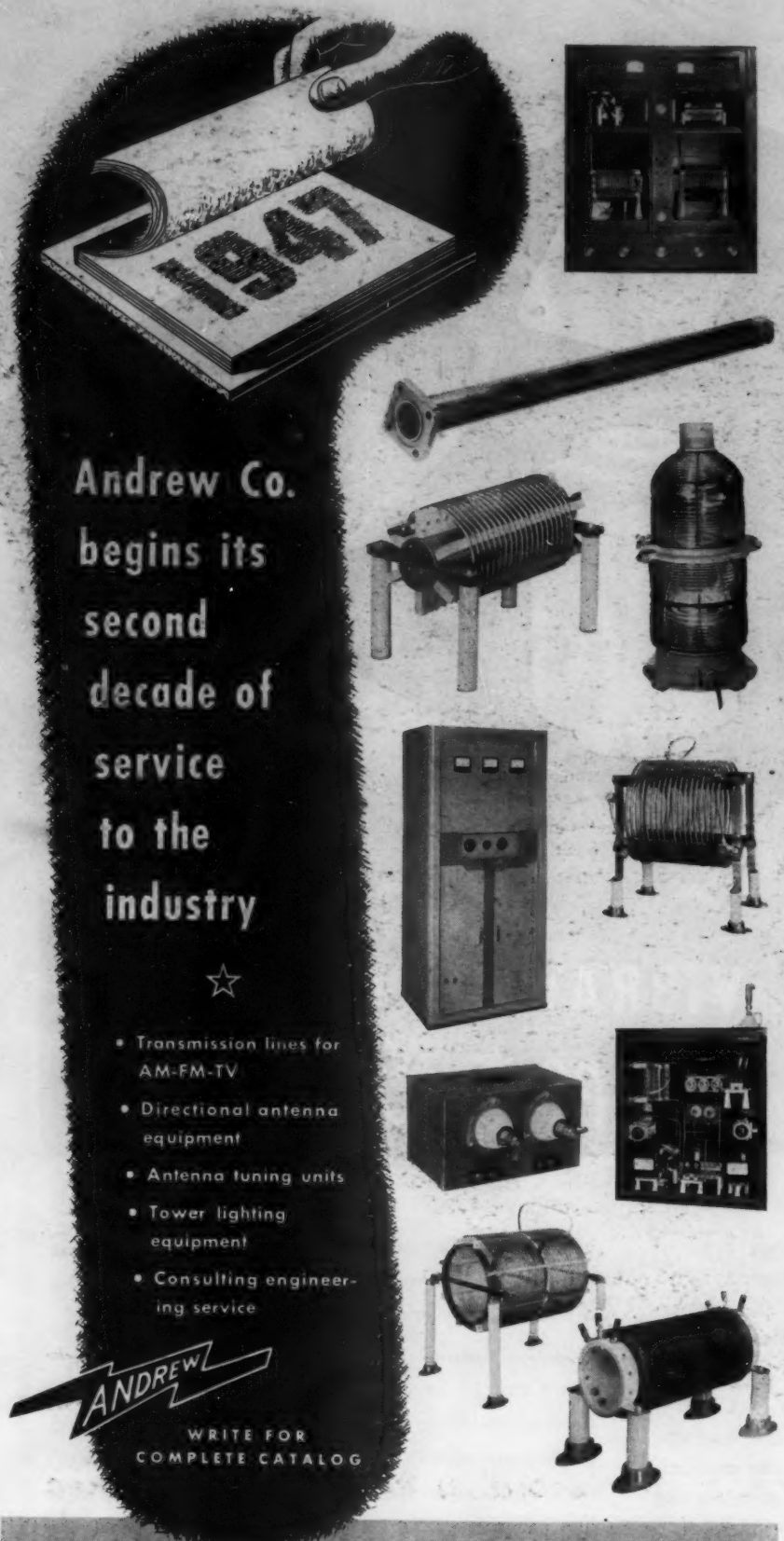
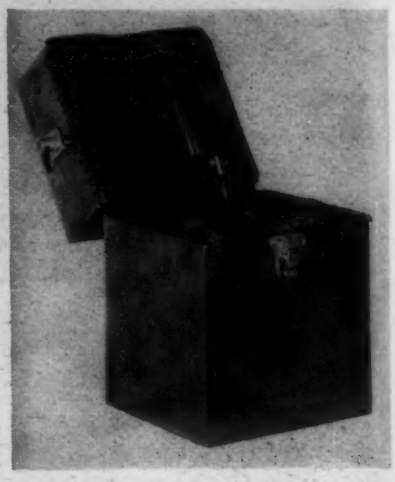


into the box or in small brass tubes which fasten to the connectors outside the box. Concentric cables are used between components in the circuit. These cables are terminated in connectors having good shield conductiyity, such as type N connectors.

The box may be used with any standard signal generator and any standard receiver covering the frequency range desired. Sensitivity of the system is limited only by the resistance pads and the sensitivity of the receiver used. The box itself presents no further limit on the over-all sensitivity.

The shielding has been found ef-



Filter to be measured is placed inside metal shield can

fective at all frequencies measured (up to 400 mc). No trace of leakage could be detected at any frequency with an electromagnetic probe. Consequently, the system can be left ungrounded. Measurements made with and without a ground connection checked over the whole frequency range.

The box is especially useful when many filters are to be measured. Each filter is mounted on its own brass plate. One reading is obtained with no filter in the circuit and then one with each filter in the circuit. The reading with each filter is then compared to the reading with no filter. The technique is accepted as standard by the Joint Army-Navy Committee on Radio Noise Filters.

Noise Suppression Circuit

BY BALANCING noise voltages in the output circuit of a diode demodulator against each other, ampli-

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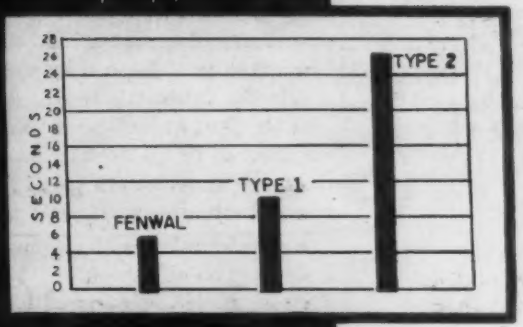

Chart shows the time required for the Fenwal THERMOSWITCH Control and two other thermostats to break contact following sudden exposure to a source of radiant heat, when adjusted approximately 10° F. above the ambient temperature. Note the fast response of the Fenwal unit.

High radiant heat sensitivity is but one of the outstanding features of the Fenwal THERMOSWITCH Control. For more information about the many facts in Fenwal's favor, send for a copy of our Thermotechnics brochure.

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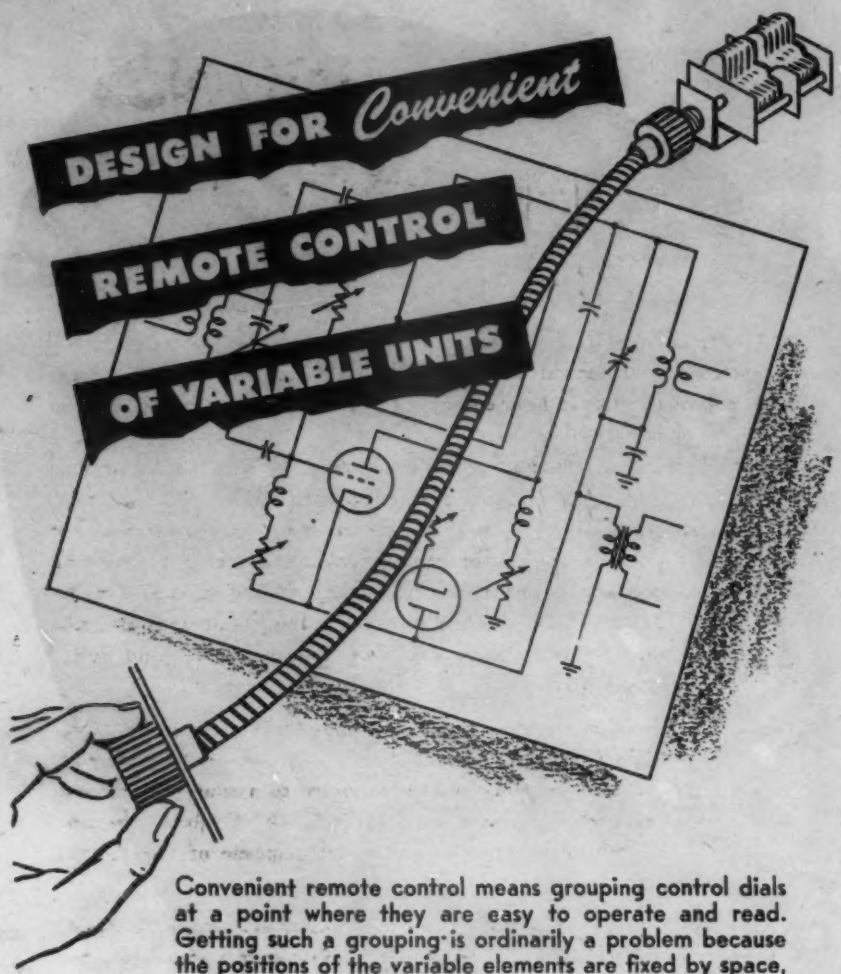

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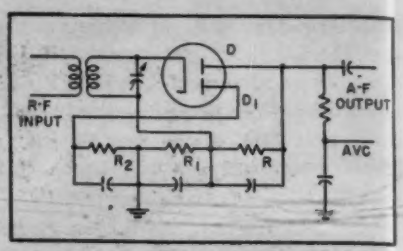

Second anode of detector diode is used to develop noise suppression voltage

tude noises are suppressed. In the circuit shown in the accompanying diagram, R and R_1 are identical (0.1 meg) and R_2 is very large (10 meg). The voltages across R and R_1 are of opposite polarity to ground. In the absence of noise, the a-c and d-c voltages across R_1 are negligible compared with those across R_2, and the voltages across R are approximately equal to the sum of those across R_1 and R_2 so that nearly the full signal voltage developed by diode D appears at the output. A noise impulse is shorted by the very large capacitor shunting R_2 but appears across R_1 where it nullifies the equal but opposite noise impulse appearing across R. (Recent Inventions, *Wireless World*, p 384 December 1946).

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capacitances and lead inductances, conventional coupling is ineffective. Furthermore, in laying out the transmitter and receiver it was desirable to use several chassis, dividing the circuit between stages. To provide a h-f coupling that would permit wide separation of stages, a new coupling network was developed.

Ordinarily the anode of one amplifier is connected directly, so far as r-f is concerned, to the grid of the following tube; between the connecting point and ground a high impedance, usually a resonant circuit, is connected. Inductance of tube leads makes direct r-f connection impossible at high frequencies, and interelectrode capacitances reduce the maximum obtainable high impedance to ground. However, if the coupling is formed by the interelectrode capacitances C_A and C_B, and the lead inductances L_A and L_B, augmented by an external series inductance L, as shown in Fig. 1A, a tuned circuit will be formed.

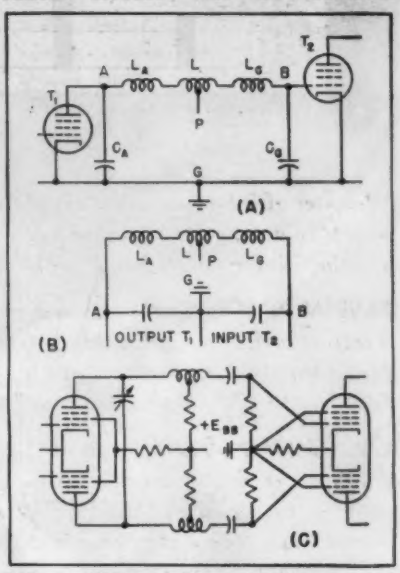
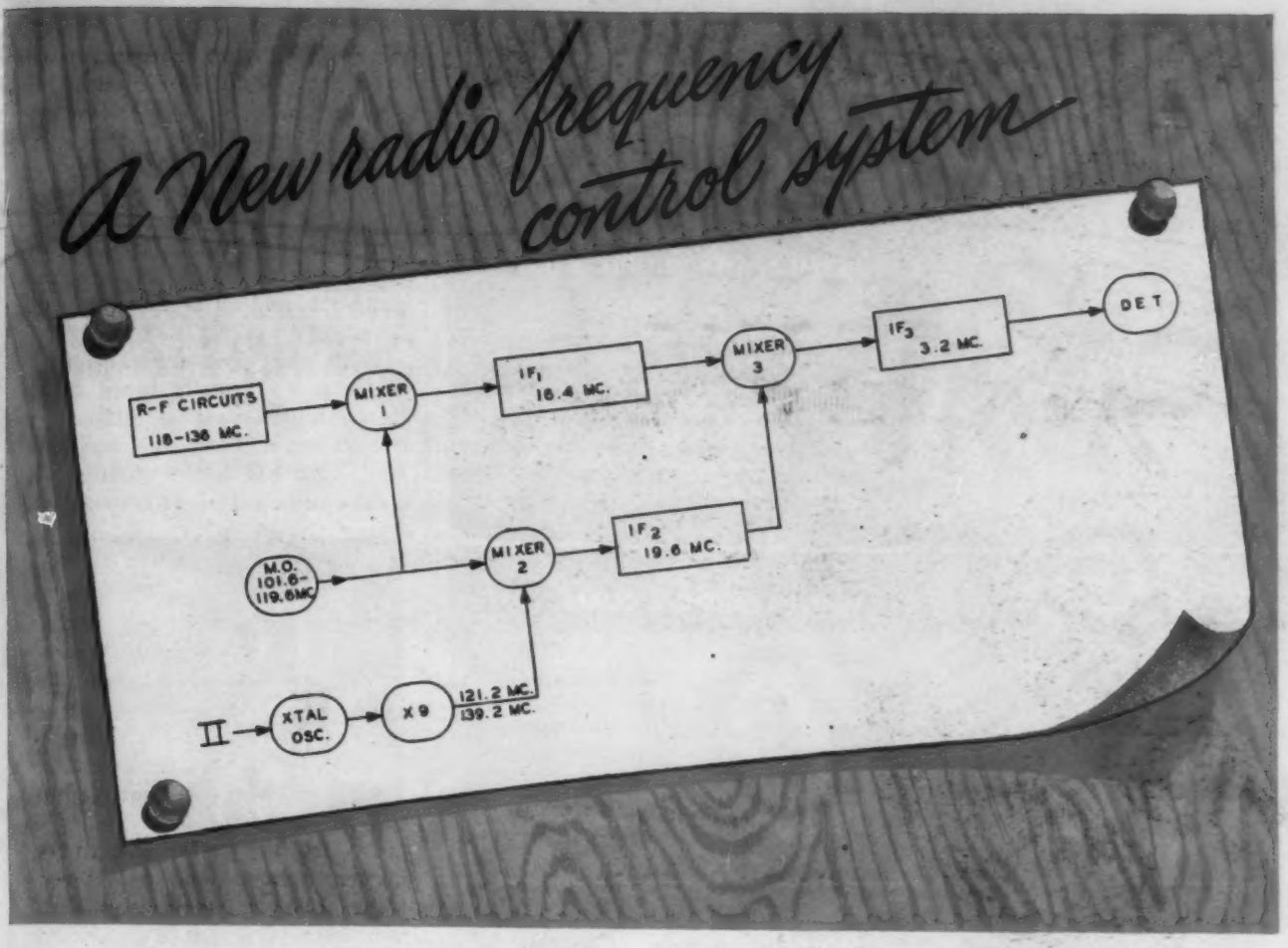


FIG. 1—UHF amplifier coupling network utilizes stray reactances

Furthermore, this tuned circuit will have two points at r-f ground potential; one between the two capacitors, the other on the tripart inductance, just where being determined by the magnitudes of the two shunt capacitances, as shown in Fig. 1B. With the capacitances and inductances proportioned so that the neutral point is on the external inductance, the circuit can be broken and a lengthy connection inserted. As the connection is at r-f ground, it need not be shielded and



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therefore will not introduce much additional shunt capacitance. If the midpoint does not fall on the external inductance, or if no external inductance is used, the circuit provides coupling, but cannot be broken. The circuit makes effective use of the unavoidable stray reactances within the tube. The network is used in both transmitter and receiver where it is necessary to break the mechanical continuity. A practical adaptation is shown in Fig. 1C.

Triode Converter

At the receiver the signal is passed directly to the mixer. An r-f amplifier is usually desirable to preserve the signal-to-noise ratio, but the mixer circuit that was developed has such low noise that preamplification was not needed. Image interference was avoided by choice of the operating frequencies. Omission of the r-f pre-amplifier greatly simplifies the uhf end of the receiver.

Multigrid mixers fail at high frequencies because lead inductances to the shield grids prevents them from remaining at a-c ground. Diode mixers are undesirable because of their low conversion gain. For these reasons triodes were considered for the mixer.

Frequency conversion in a triode, as in any converter, involves three principle voltages: the signal input voltage, the heterodyning voltage (both of which are applied between grid and cathode), and the intermediate voltage (which appears in the plate circuit along with other nonessential voltages). If a push-pull connection of two triodes is used for the converter, two of these three voltages must appear in the circuit in push-pull, and the third must be in the same phase in both tubes.

A symmetrical dipole and bal-

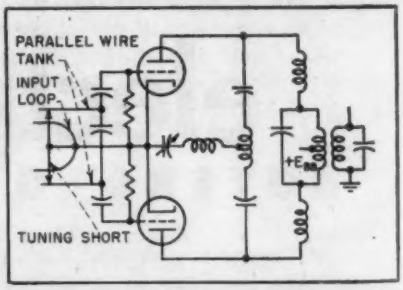

FIG. 2—Triode mixer has balanced input and output and a symmetrical, self sustaining heterodyning loop

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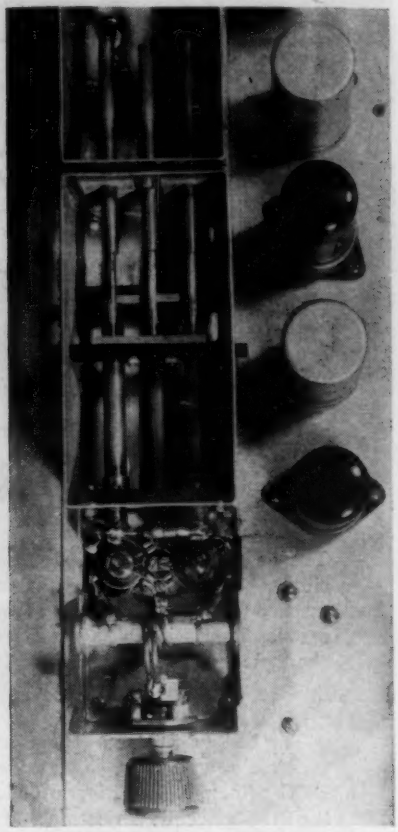
anced line is used for the input, so it is most convenient to apply the uhf signal in balance to the converter. The local oscillator voltage is then applied in equal phase to both tubes. Then the intermediate-frequency output appears in push-pull in the anode circuit. There are thus two loops; a balanced (push-pull) one, and an asymmetrical one arranged as in Fig. 2.

With the asymmetrical circuit, which is not usually tuned to the local oscillator, it is difficult to couple power from the oscillator. An additional series tuning element can be added to resonate the



Triode mixer has low noise

impedance into which the oscillator operates. This oscillator tuning element is added in a part of the circuit through which balanced currents do not flow. Furthermore, because the asymmetrical grid circuit presents a low impedance to the oscillator making it difficult to develop a large local signal on the mixer grids, the input impedance of the mixer grids can be increased at the oscillator frequency by making the asymmetrical anode load slightly inductive. If the plate circuit inductance is properly proportioned, the loop itself oscillates. A

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MAR. *Prepared by* SYLVANIA ELECTRIC PRODUCTS INC., Emporium, Pa. 1947

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separate local oscillator is then not needed, which eliminates the noise introduced by a separate tube. As far as the conversion action of the push-pull triodes is concerned, it makes no difference how the heterodyning potential is generated between grids and cathodes; mixing being determined solely by the magnitude of this potential and the nonlinearity of the transfer characteristic.

Just as back coupling was introduced in the asymmetrical loop by placing inductance in the anode circuit that would be reflected into the grid circuit through the grid-anode capacitance as a negative impedance, so back coupling can be used in the balanced circuit to increase the input impedance of the triodes to the uhf signal, thereby decreasing the loading on the input circuit and making it possible to develop a large input potential.

Were the push-pull mixer perfectly balanced, there would be no interaction between balanced and asymmetrical loops. However, in a practical circuit there will be some unbalance and hence interaction. Thus the two circuits cannot lie close in frequency. This consideration determines the intermediate frequency. Too low an i-f would place the two circuits close together in frequency. To render the coupling harmless the heterodyning frequency should be at least one twentieth the incoming signal frequency (*Philips Technical Review*, p 121 April 1946; p 194 July 1946, the first being a description of the transmitter, the second governing the receiver).

Self Balancing Phase Inverter

U. S. Patent No. 2,383,846, Granted Aug. 28, 1945

To James Bruce Crawley
Radio Corp. of America

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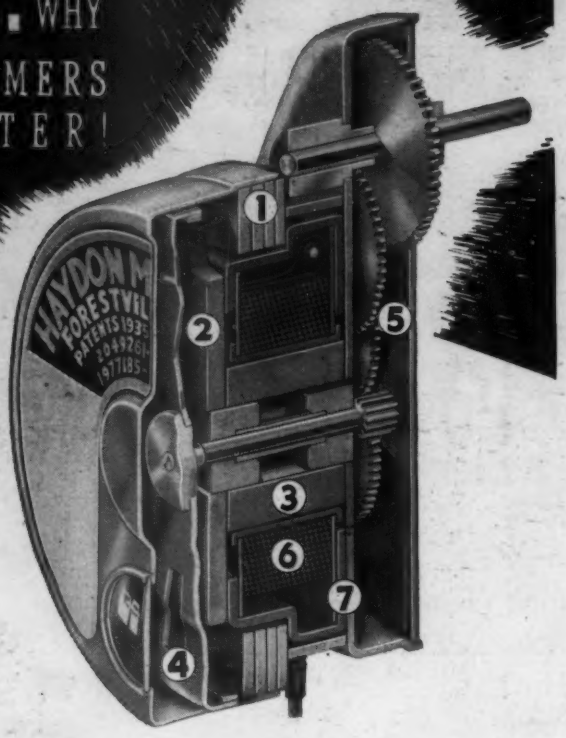

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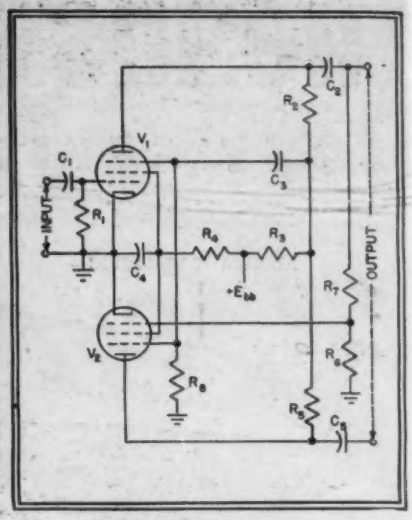

FIG. 1—Duplex feedback preserves balance of inverter

magnitude to the input to that tube, is obtained from potential divider $R_6 - R_7$ and fed to the grid of V_2. Because of the reversal of phase introduced by V_1, the input to V_2, and hence its output, is the reverse of that of V_1, and thus the output of the circuit is balanced about ground.

However, as seen from the circuit, the suppressor grids of the two pentodes used in this inverter are not connected in the usual manner. Resistor R_3 is common to the plate circuits of both tubes. The suppressor grids of the two tubes are connected to each other and also, through d-c blocking capacitor C_5, to the high side of R_3. Any unbalanced voltage in the common portion of the plate circuit of the inverter will thus appear across the suppressor grids of the two tubes. In particular, that unbalanced voltage so fed back will be of such polarity as to cause degeneration in the tube producing the larger signal output and regeneration in the tube producing the smaller signal output. From this feedback action the inverter balances itself.

Output of a high-frequency oscillator is used to test the conductance between elements of vacuum tubes. A cathode-ray indicator tube gives an indication of the loading presented to the oscillator by the tube under test. (2,380,095, Tube Testing Device, Walton De Verter, July 10, 1945).

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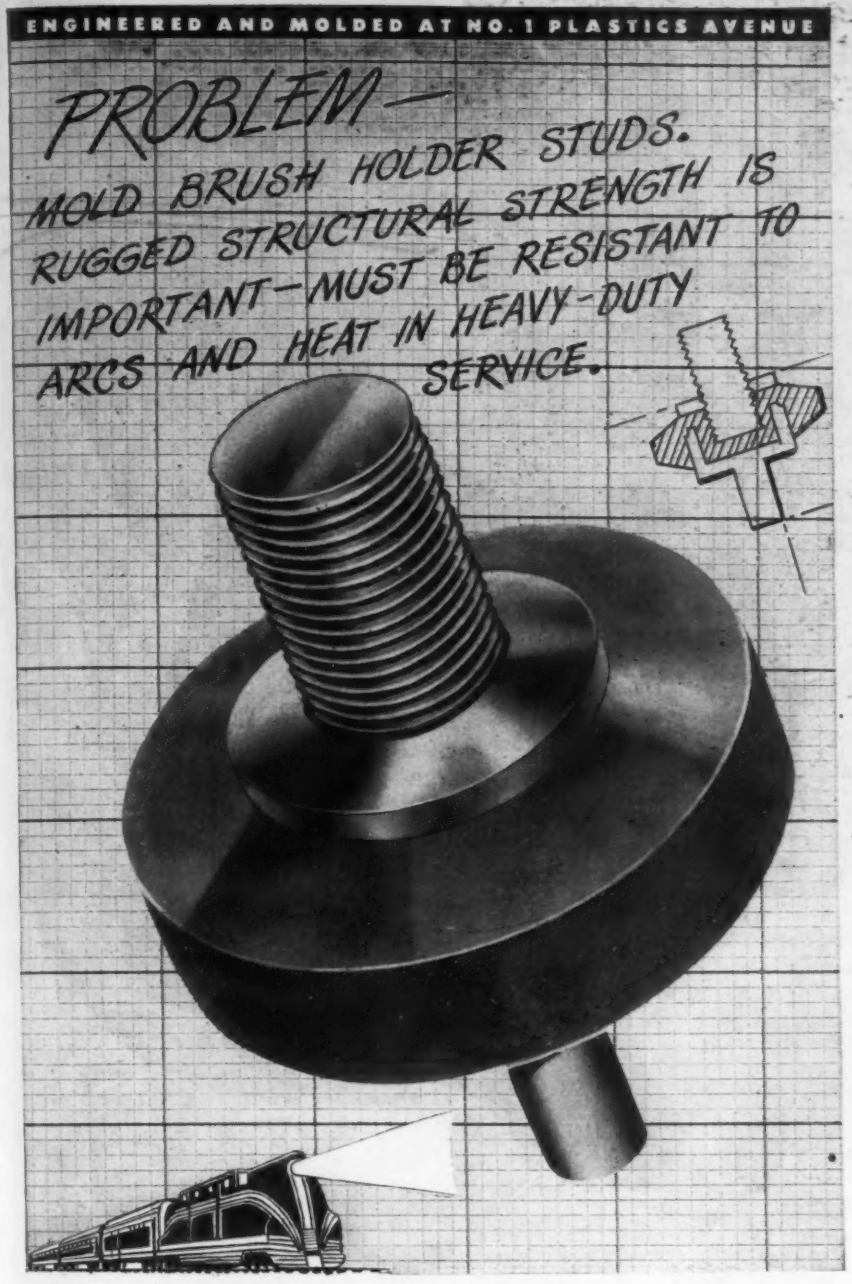

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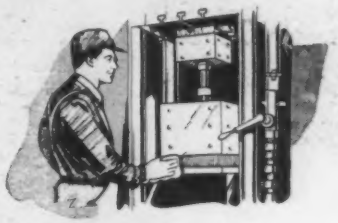

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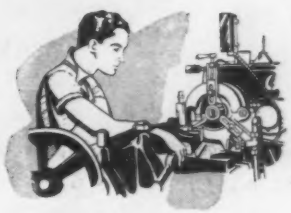

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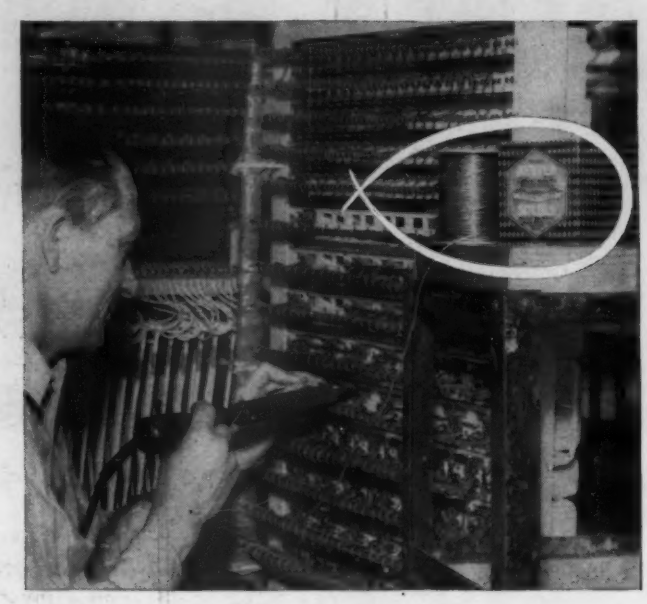

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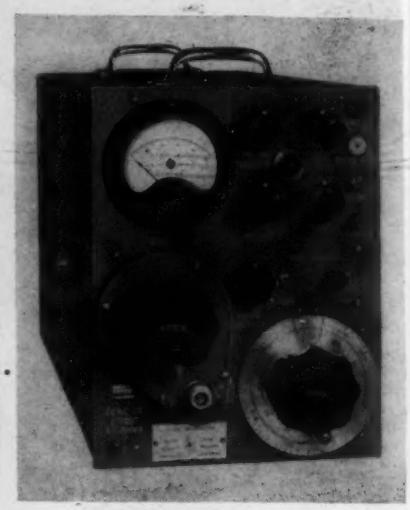
• Kester Cored Solders are available in a wide range of strand and core sizes, with the right combination of alloy and flux to give you the right solder for your specific job.

• Kester experience is at your service to determine the best solder formula and practice for your operation. Get the benefit of this experience without obligation by consulting Kester engineers on any solder problem.

KESTER SOLDER COMPANY
4204 Wrightwood Avenue, Chicago 39, Ill.
Eastern Plant: Newark, N. J.
Canadian Plant: Brantford, Ontario

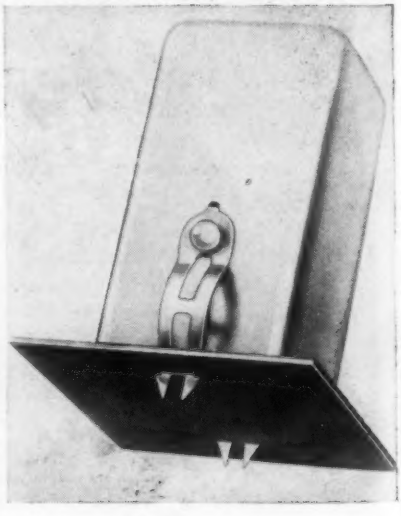
KESTER
Cored Solders
STANDARD FOR INDUSTRY



ment, obtaining antenna data or measuring standing-wave ratios, and reading single-stage or conversion gain, signal-to-noise ratios, circuit Q, or transmission line characteristics. The unit will supply accurately known voltages ranging from 0.1 microvolt to 0.1 volt. The r-f output may be continuous, amplitude-modulated, pulsed, or square-wave modulated. Pulse length can be readily controlled between 2 and 50 microseconds, and pulse rate is variable from 60 to 3,000 times per second.

Shield Can Fastener (20)

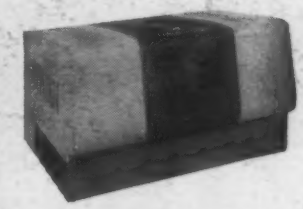
THE PALNUT CO., 77 Cordier St., Irvington, N. J. The Palnut shield can fastener snaps quickly into chassis holes and automatically locks. It will not let go until deliberately released. When inserted in chassis holes, two pronged ends

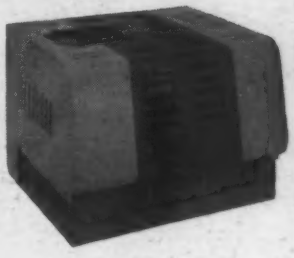


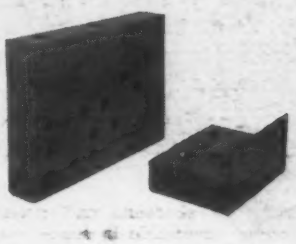
At Your Service

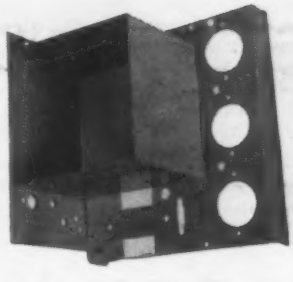
to help you with your

SHEET METAL FABRICATION REQUIREMENTS









SHEET METAL PRODUCTS—*such as:*

INSTRUMENT PANELS, RADIO COMMUNICATION CASES and ENCLOSURES, OSCILLATOR BOXES, CHASSIS and CABINET ASSEMBLIES, RACKS and SPARE PARTS BOXES, WATERPROOF CABINETS and BOXES, METAL STAMPINGS, FORMING and WELDING of FERROUS and NON-FERROUS METALS.

We specialize in RADAR and RADIO COMMUNICATION METAL PRODUCTS. "Whistler and Wiedermann Setups" used for economic and speedy production.

We can assure you of excellent workmanship and prompt deliveries. Send us your blueprints and specifications. We shall quote you immediately.

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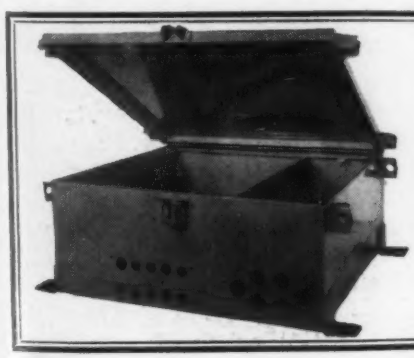
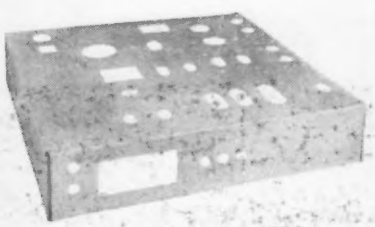
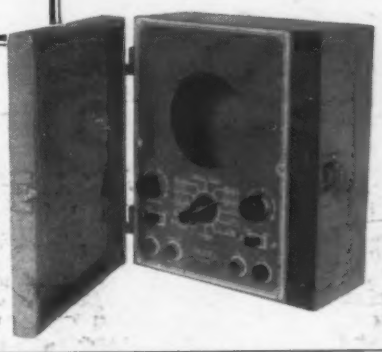
144-146 CENTRE STREET BROOKLYN 31, N. Y.

Telephone, MAin 4-7395







WIRE-WOUND Controls

Series 58 rheostats and potentiometers, available in single, dual and triple section units (as here shown). Available with attached power switch.

★

Series 42 multiple-unit wire-wound controls, available in assemblies from 2 to 18 sections in tandem and operated by a single shaft.

★

Series 43 midget wire-wound controls in single, dual and triple section units. Available with attached power switch.

★

Series MH or the famous "Humdinger" extra-compact rheostat or potentiometer. Wire winding held in grooved fibre base. Body only 9/32" deep.

★

Widest selection of resistance values, taps, tapers, terminals, shafts, etc.

★ You can entrust your wire-wound control problems to Clarostat, with complete confidence, because: (1) Clarostat has wire-winding experience second to none in the industry; (2) Clarostat has outstanding winding equipment designed, developed and built by its own engineers; (3) Clarostat spent two decades perfecting wire-wound rheostats and potentiometers; (4) Above all, Clarostat has an enviable reputation to maintain. Therefore, try Clarostat with those wire-wound control problems or requirements.

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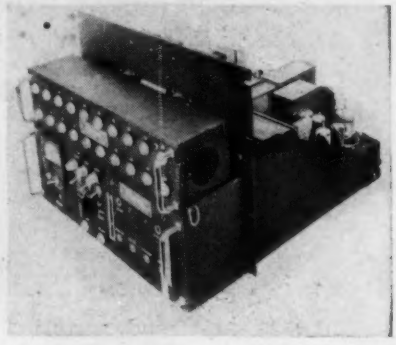
CLAROSTAT Controls and Resistors

CLAROSTAT MFG. CO., Inc. · 285-7 N. 6th St., Brooklyn, N. Y.

compress to enter, then snap outwardly when pushed through. The prongs grip the underside of the chassis with a continuous spring pull that holds the can firmly to the chassis. When mounted according to specifications, this fastener accommodates a wide range of chassis thicknesses. Variations in hole locations in cans and in chassis thickness are easily taken care of by the long spring arch construction.

Grid Pulse Life Tester (21)

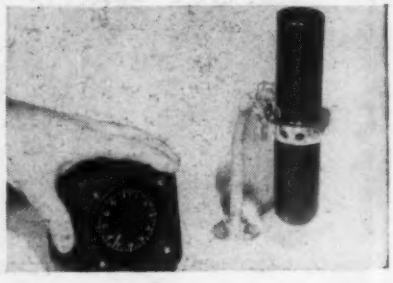
CHATHAM ELECTRONICS, 475 Washington St., Newark 2, N. J. New equipment for testing receiver type tubes under pulsed operating conditions consists of four units. The



modulator unit delivers a positive pulse adjustable from 50 to 350 volts. Pulse current of 10 amperes has a duty cycle of 0.01. Width of the pulse can be varied between 1 and 25 microseconds. Repetition rate is variable between 500 and 2,500 times a second.

Electron Gun Compass (22)

MINNEAPOLIS-HONEYWELL REGULATOR CO., 2753 Fourth Ave., S., Minneapolis, Minn. Containing no moving parts, a new device depends upon an electron beam aimed at a four-segment target to provide direction signals for guiding a ship or plane to a preset course. The magnetic field of the earth makes



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The K-TRAN is more *economical*, more *compact* and gives *better performance* than old style I. F. Transformers. Its use assures quick deliveries.

AUTOMATIC MICA TRIMMERS are the standards of the Radio Industry.

Specify and use AUTOMATIC standard components for assurance of quality and service.

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RACON—world's largest and leading manufacturer of air column horns, speakers and driving units offers you the most complete line—a unit and speaker for every conceivable PA or sound requirement.

Competitively priced, RACONS assure maximum efficiency and high-fidelity "true tone" reproduction. Our driving units give 60 watts peak and 30 watts continuous output at lowest watt of energy input. All-Weather construction and Stormproof Material make RACON speakers impervious to any climatic condition. RACON Acoustic Material prevents resonant effects.

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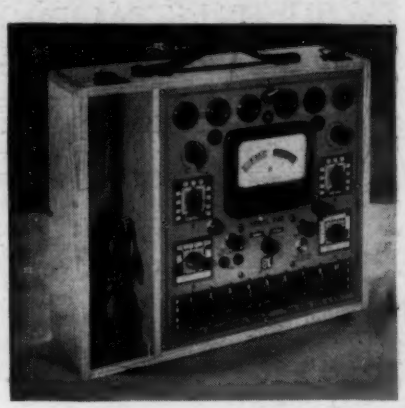
the beam deflect to the west, but the compass indicator is oriented to read conventionally north. The Cathotrol can be tied in to an autopilot for exact control of aircraft. Other uses include that of magnetometer substitute in prospecting for oil and ores.

Tube Tester (23)

ELECTRONIC MEASUREMENTS CORP., 114 Liberty St., New York 6, N. Y. The Series 200 mutual conductance



tube tester illustrated checks all tubes according to mutual conductance on a micromho scale that is also marked for "good" and "reject" values.

Adjustable A-C Supply (24)

SUPERIOR ELECTRIC CO., 277 Church St., Bristol, Conn. The new voltbox a-c power supply has been designed primarily to meet the needs of electric light company testmen but the many features of this instrument will prompt its use in diversified applications. The unit offers a compact, portable source of metered, continuously adjustable a-c voltage and current. Three ranges of output voltages and two ranges of output current are available. The variable voltage and current feature is achieved by two Powerstate variable transformers operating in conjunction with auxiliary transformers. Voltage and current are varied independently and are electrically isolated from each other. For metering purposes, a triple-range voltmeter and a double-range ammeter are supplied. When it is required to measure external voltages and currents, these meters can be employed for such purposes by throwing the lever-action switches located below

from the LARGEST . . . to the SMALLEST

EACH

UNBRAKO

Reg. U. S. Pat. Off.

SOCKET SET SCREW

with the *KNURLED* CUP POINT

This extremely small "Unbrako" Socket Set Screw is a fullfledged Self-Locker—knurled cup point and all.

is a product of

Continuous Research and Precision Manufacture

perfect in every detail . . . no matter how large or small the "Unbrako".

Each has the accuracy, strength and dependability so important in the electronic and small precision instrument field . . . each has the internal wrenching feature that facilitates compact designs . . . each is a *Self-Locker* because its knurled cup point digs-in and stays tight regardless of the most chattering vibration . . . and each can be easily backed-out with a wrench and used over and over again any number of times.

Write for your "Unbrako" Catalog, it describes "Unbrako" Socket Screw Products in detail.

"Unbrako" and "Hallowell" Products are sold entirely through distributors.

Knurling of Socket Screws originated with "Unbrako" in 1934.

"UNBRAKO" SOCKET HEAD CAP SCREW

The "Unbrako" Socket Head Cap Screw has a knurled head which makes it slip- and fumble-proof, though the fingers and head be ever so oily, therefore, it can be screwed-in faster and farther before it becomes necessary to use a wrench.

"UNBRAKO" SOCKET SET SCREW

The "Unbrako" Socket Set Screw with the knurled threads in a *Self-Locker*, too, for Flat, Oval, Cone, One-Half and Full Dog Points.

Pat'd & Pats. Pend.

"HALLOWELL" KEY KIT

You can't screw socket screws in or out without a hex socket wrench, so why not get our No. 25 or No. 50 "Hallowell" Hollow Handle Key Kit which contains most all hex bits.

KITS: Pats. Pend.

OVER 44 YEARS IN BUSINESS

STANDARD PRESSED STEEL CO.

JENKINTOWN, PENNA., BOX 596 · BRANCHES: BOSTON · CHICAGO · DETROIT · INDIANAPOLIS · ST. LOUIS · SAN FRANCISCO

Match her skill with dependable solder

Delicate soldering operations by skilled workers call for a solder of proven dependability. Your investment in labor-time and cost of materials should be protected—not to mention that most valuable business asset, your reputation.

You will be free from soldering comebacks and worries of all kinds when you standardize on Glaser Plastic Rosin Core Solder.

Only virgin metals go into this fine "scientific formula" solder. No vitiating "scrap" content to cut down costs, at the risk of lowering the quality of your product and injuring your good name.

Every day increases the list of prominent manufacturers who capitalize on the dependability of Glaser Plastic Rosin Core Solder and other Glaser Products.

Insist on "Glaser" when ordering solder and flux—the line that "gives you more" yet costs no more.

OTHER GLASER PRODUCTS

Silver Brazing Solder and Flux
Fluxes for every purpose
Lead Products of every description
Lead Lining of acid and plating tanks

Glaser Plastic Rosin Core solders exceed Government specifications in purity and are guaranteed to conform with A.S.T.M. Class A specifications.

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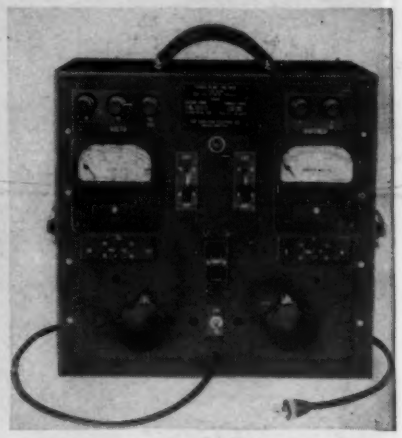
31 Wyckoff Avenue, Brooklyn 27, N. Y.
Our 24th year of dependable service to American industries.

The Quality Line

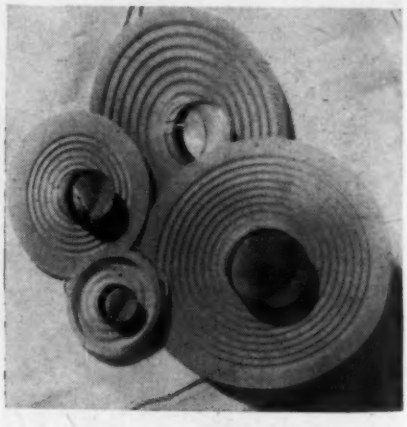
Glaser SOLDER PRODUCTS



each meter. The circuit has been designed to permit the use of this device on either 115 or 230 volt, 50/60 cycles power lines. The output voltage ranges are 0-30, 0-150, and 0-300 volts while the current ranges are 0-5 and 0-20 amperes. A circuit-breaker offers complete instrument protection.

Aluminum Voice Coil Speakers (25)

GENERAL ELECTRIC CO., Syracuse, N. Y. The line of loudspeakers currently being manufactured uses an aluminum foil based voice coil, as illustrated. The use of aluminum



offers advantages in that it can handle higher wattages; the voice coil is unaffected by temperature and humidity, the coil will not warp or crack, and better control of gaps is afforded.

D-C Power Supply (26)

SUPERIOR ELECTRIC CO., 177 Church St., Bristol, Conn. The 0-3,000-volt d-c power supply illustrated has been designed for continuous duty, small regulation, and easily ad-

CORWICO

WIRES

at work

Photo courtesy of EMERSON Radio & Phonograph Corp.

WHY ARE CORWICO WIRE PRODUCTS SPECIFIED BY THIS LARGE RADIO MANUFACTURER?

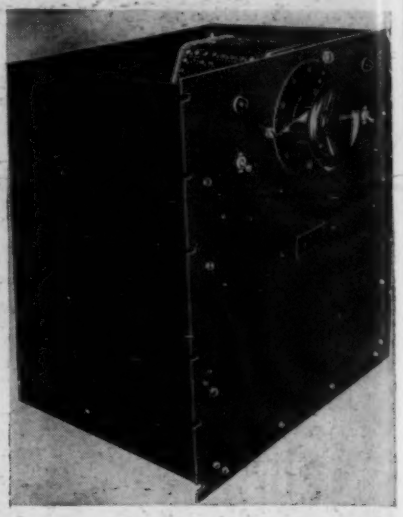
Because their ENGINEERING Department values their faithful performance of the requirements of insulation resistance and voltage breakdown . . .

Because their PRODUCTION Department finds that they possess the essential qualities which permit easy pushback or mechanical stripping . . .

Because their PURCHASING Department finds that these quality products, backed by dependable service, are sold at prices that spell true economy . . .

CORNISH WIRE CO., INC.

15 Park Row • New York City, 7



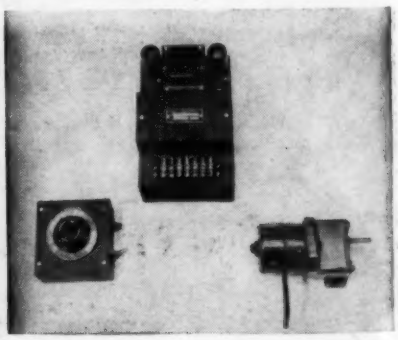
justed output voltage. The maximum d-c output current is 0.5 ampere. It operates from a 115-volt, single-phase, 50/60-cycle source. The power supply uses a full-wave bridge rectifier consisting of four type 866/866A tubes. A time-delay relay is provided which allows the filaments to be adequately heated before high voltage is applied. All major components are either potted or hermetically sealed.

Contact Tape (27)

D. E. MAKEPEACE CO., Attleboro, Mass. Bar contact tape for use on spring contact arms can be supplied by the company, which also provides an assembly service when desired. Palladium and palladium alloys on pure nickel base, silver tape or other combinations can be attached to contact arms to provide low-cost and satisfactory make and break of circuits.

Remote Position Control (28)

YARDENY LABORATORIES, INC., 105 Chambers St., New York 7, N. Y. The Synchro-Link works on the



PLASTICON* ASG Silicone-Filled GLASSMIKES

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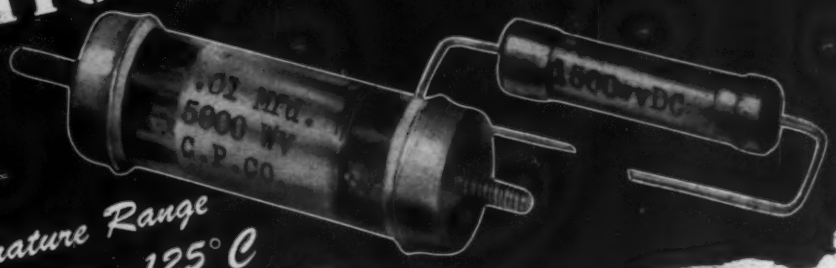
FOR HIGHER VOLTAGES



Extreme Temperature Range from Minus 60° C to Plus 125° C

From 600 to over 30,000 Volts

Modern functionally designed capacitors. Metal ferrules are soldered to silver bands used to each end of heavy-walled glass tubes. This vacuum-tight assembly is fungus-proof and passes Signal Corps, Air Corps and Navy thermal cycle and immersion tests.

Announcing an illustrated technical booklet on uses of

PLASTICON GLASSMIKES*

Contains the following subjects:—

- **Glassmike characteristics and design data**
- **Comparison of Glassmike and Mica Capacitors**
- **Uses of Glassmikes for improved RF and Audio bypassing**
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- **Instrument capacitors**
- **And many other applications**

Come in and visit our exhibit at the I. R. E. show, March 3-7, incl.

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Far beyond the moon...

Hathaway Type S12-A 12-element Portable Oscillograph
• Very small • Automatic • Simple to operate

ONE OF A COMPLETE LINE OF RECORDING OSCILLOGRAPHS AND HIGH-SPEED GRAPHIC INSTRUMENTS

Men talk of trips to the moon nowadays but science has already travelled far beyond in its search for truth . . . from inconceivable distances come faint glimmerings that reveal secrets of distant universes.

Just as these messages from space are interpreted by MEASUREMENTS, so has every scientific discovery resulted from our ability to build and to use ACCURATE MEASURING INSTRUMENTS.

To keep abreast with the ever-changing needs of modern research, Hathaway engineers are constantly working on new measuring instruments, constantly improving older ones. Whatever may be YOUR new problem in MEASUREMENT OR CONTROL, Hathaway experience can help you.

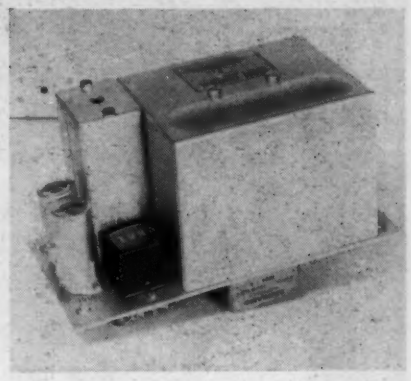
WRITE FOR TECHNICAL BULLETIN SP-167A

Hathaway
INSTRUMENT COMPANY
1315 SO. CLARKSON STREET • DENVER 10, COLORADO

principle of a self-balancing electronic bridge. It consists of a master control with calibrated dial, a vacuum-tube chassis, and the load control potentiometer geared to a motor or otherwise coupled to the load. Several slave units can be controlled by the same master station. Further details are available in a single-sheet leaflet.

Improved Fleet Control (29)

THE HAMMARLUND MFG. CO., Inc., 460 West 34th St., New York 1, N. Y. An improved model of the dial-operated fleet control system for taxis, police, and utility cars



includes a circuit to ring a bell and flash a light when the particular vehicle is called. The light remains on to warn an absent operator on his return that he has been called.

Moving-Coil Pickup (30)

COOPER MFG. CO., 17 Hanway St., London, W. 1., England. A new lightweight moving-coil pickup requires a pressure of 0.5 ounce on the record and has a response essentially flat from 30 to 12,000 cycles. Replacement of the sapphire stylus has been facilitated by use of a special tool. The device is robust enough not to be easily damaged by dropping on the record.

Sound System Pads (31)

GENERAL ELECTRIC CO., Syracuse, N. Y. Wire-wound L-pads and T-pads for sound systems, covering impedance ranges from 8 to 600 ohms, have just been announced. The T-pads may be used as variable attenuators in stable line impedance circuits, while the L-pads

For phono-combinations that aren't being born in a hurry . . .

If you manufacture the kind of combination that takes its precious time coming off the drawing board – and off the assembly line – Garrard is your record changer.

For the most part, Garrard changers have been finding their way into those custom-built assemblies where every component is hand-picked, without a sidewise glance at cost. Your finest combinations are made that way, and there is every reason why you can and should select Garrard.

It's as simple as this: with Garrard in your combination, you can feature the changer as you feature cabinetry and tone quality. You can point up the watch-like construction; the exclusive governor-controlled, speed-regulated motor; the non-slip spindle . . . and more. Most important . . . Garrard has the "look" of belonging in distinctive sets.

Send for a sample changer. Garrard Sales Corporation, 315 Broadway, New York 7, New York.

PRECISE AS A WATCH

1. Exclusive speed-regulated, governor-controlled motor
2. Completely automatic intermixing
3. True tangent, jewelled-pivot tone arm
4. Exclusive non-slip spindle
5. Automatic stop
6. Heavy fly-wheel action built into turntable
7. Only one operating control required
8. Full swivel tone arm for changing needles
9. Kind to fragile records; no knives or trick spindles

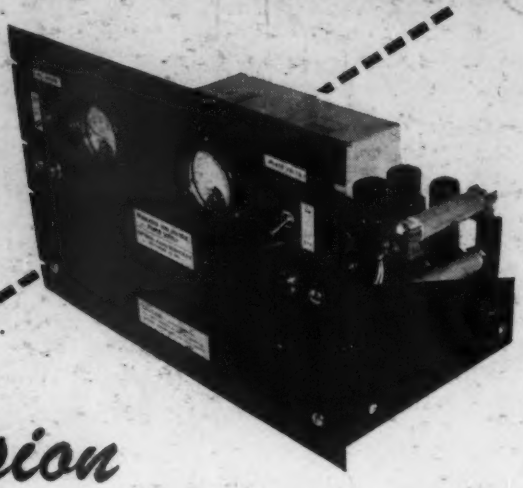
. . . they ask for it by name . . .

GARRARD

WORLD'S FINEST AUTOMATIC RECORD CHANGER

GARRARD ADS APPEAR CONTINUALLY IN EVERY IMPORTANT CONCERT PROGRAM AND IN LIFE • SATURDAY EVENING POST • NEW YORK TIMES MAGAZINE • HOUSE BEAUTIFUL • HOUSE AND GARDEN • RECORD REVIEW

Electronic Regulated
POWER SUPPLIES



★ Precision

★ Accuracy

★ Performance

Built to rigid U. S. Government Specifications

SPECIFICATIONS

INPUT—115 v. 50-60 cycle

REGULATIONS—Less than 1/20 volt change in output voltage with change of from 100-140 V.A.C. input voltage & from NO-LOAD to FULL-LOAD (over very wide latitude at center of variable range)

RIPPLE—Less than 5 millivolts at all loads and voltages

DIMENSIONS—Fits any standard rack or cabinet (overall: 19 in. wide; 12¼ in. high. 11 in. deep; shipping wt.—100 pounds)

TYPE A—VARIABLE FROM 210-335 V.D.C. @ 400 M. A.
TYPE BI—VARIABLE—TWO RANGES: 400-600 V. D. C. @ 125 M. A. and 600-890 V. D. C. @ 125 M. A.

CONSTRUCTION FEATURES

Weston model 301 (or equal) millimeter and voltmeter • Separate switches, pilot lights, and fuses for FIL and PLATE VOLTS • All tubes located on shockmount assemblies • Fuses mounted on front panel and easily accessible • Can vary by turning small knob on front of panel. Can easily modify Type BI from POSITIVE to NEGATIVE output voltage • Individual components numbered to correspond with wiring diagram.

Rigid construction: components designed to withstand most severe military conditions—physical and electrical; were greatly under-rated.

All units checked and inspected at 150% rated load before shipment.

Tube complement: Type A: 2-836; 6-6L6; 2-6SF5; 1-VR150; 1-VR105
Type B1: 2-836; 2-6L6; 2-6SF5; 1-VR150; 1-VR105

IMMEDIATE DELIVERY

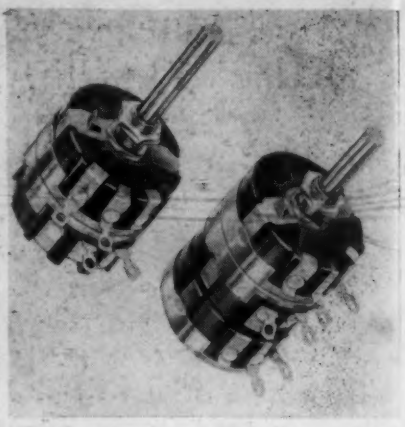
NET PRICES—F. O. B. BALTIMORE, MD.

TYPE A—$185.00 **TYPE BI—$179.00**

Complete with tubes and ready to plug in—Prices subject to change without notice

NATIONAL RADIO SERVICE CO.

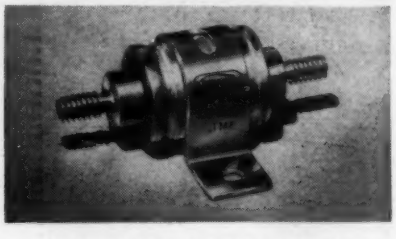
Reisterstown Rd. & Cold Spring Lane • Baltimore 15, Md.



have application as individual volume controls for multiple speakers or as attenuation controls for constant impedance at either the source or load. Rated at a maximum power dissipation of 2.5 watts, the units have a continuous range of from 0.5 to 30 decibels attenuation in 90 degrees of rotation, the last ten percent affording infinite attenuation.

High Current Capacitors (32)

SOLAR MFG. CO., 285 Madison Ave., New York 17, N. Y. Small filter capacitors capable of continuous use at currents up to 100 amperes with line voltages up to 250 volts



a-c are suitable for 3-terminal network filters to attenuate radio interference from motors and other rotating equipment. Capacitance values up to 0.75 microfarad are available.

Electronic Timer (33)

SPECIAL PRODUCTS CO., Silver Spring, Md. The Speco-Rhein electronic timer is useful for time delay action in timing short intervals and for continuously repeating a definite cycle of time. The new unit is compact in size, and is housed in a cast aluminum case for wall mounting. The standard unit provides timing ranges from 1/10 second to 60 seconds, although other

1 WON'T BURN OR SUPPORT FLAME

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and Added Sales Appeal

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4 RESISTS HEAT AND OXIDATION

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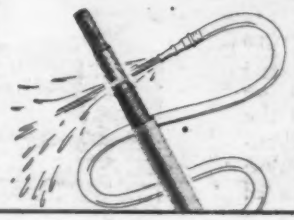

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Offer "Immediate Delivery" today and you can sell electrical products in quantity regardless of quality. But will they stay sold . . . or will dissatisfied customers run up your operating costs with demands for replacements, repairs or servicing?

There's no substitute for quality when performance has to sell your product and keep it sold. And where wire is concerned you can guard against future trouble and build a reputation that will increase sales by wiring with *permanently insulated* Rockbestos wires, cables and cords. They are built to outlast your product . . . insulated with heat, flame and age resistant impregnated asbestos to eliminate failures caused by overloads, high ambient temperatures and hard usage under severe operating conditions.

Let Rockbestos *permanently insulated* wires help guarantee the performance of whatever you make . . . aircraft, buses, cranes, electronic calculators and controls, locomotives, motors, radio transmitters, ranges and hundreds of others. For recommendations or a catalog write to:

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The Wire with Permanent Insulation

A few of the 125 permanently insulated wires, cables and cords developed by Rockbestos to protect performance and give lasting service.

ROCKBESTOS FIREWALL HOOKUP WIRE

This heat, flame and moisture resistant wire, insulated with high dielectric tapes and impregnated felted asbestos and covered with color-coded, lacquered glass braid, has a maximum operating temperature of 125° C. Ideal for radios, television, amplifiers, calculators or small motor, coil, dynamotor and transformer leads. No. 22 to 4AWG in 1000 volt rating — No. 12, 14 and 16 AWG in 3,000 volt, also in twisted pair, tripled, shielded and multi-conductor constructions.

ROCKBESTOS THERMOSTAT CONTROL WIRE

A multi-conductor control wire for low voltage intercommunications, signal and temperature control systems. Its asbestos insulation and steel armor assure trouble-free circuits. Sizes No. 14 to 18 AWG in two to five conductors with .0125", or .025" — or (for 115 volt service) .031" impregnated asbestos insulation.

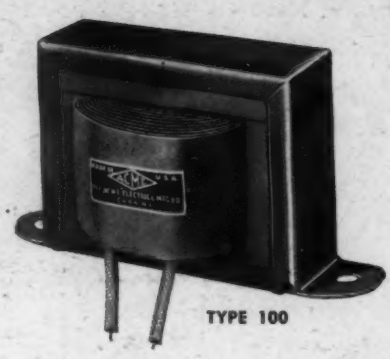
ROCKBESTOS A.V.C. MOTOR LEAD CABLE

Use this apparatus cable for coil connections, motor and transformer leads exposed to overloads and high ambient temperatures. Insulated with impregnated felted asbestos and varnished cambric, and covered with a heavy asbestos braid, it is heat-proof and resistant to oil, grease, moisture and flame. Sizes 18 AWG to 1,000,000 CM.

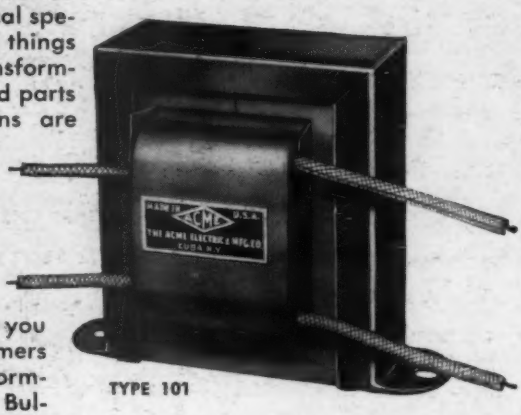
NEW YORK BUFFALO CLEVELAND DETROIT CHICAGO PITTSBURGH ST. LOUIS LOS ANGELES SAN FRANCISCO SEATTLE PORTLAND, ORE.

HOW MANY VARIATIONS ARE THERE TO A STANDARD DESIGN

Acme Electric transformers are designed to basic standards to which variations can be adapted to exactly meet the requirements of the application. For example, Mounting Type 100 is for horizontal mounting while type 101 is for vertical mounting, yet both are basically identical. And in either case, one or both mounting legs may be turned down for side mounting to save space. The number of leads or terminals may also be varied to comply to the electrical specifications desired. All things considered, Acme transformers made from standard parts to special specifications are available in hundreds of ratings and to exactly the physical dimensions, design and electrical characteristics you require. Acme TransformerEngineers will be glad to assist you by designing transformers to improve the performance of your product. Bulletin 168 gives more details.



TYPE 100

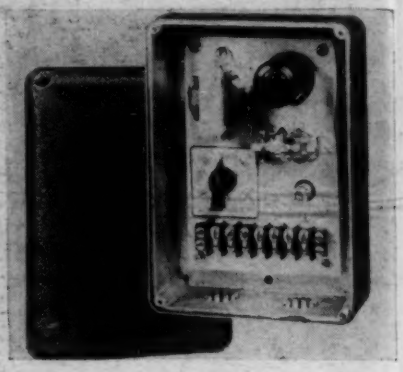


TYPE 101

ACME ELECTRIC CORPORATION

31 Water St. CUBA, N.Y.

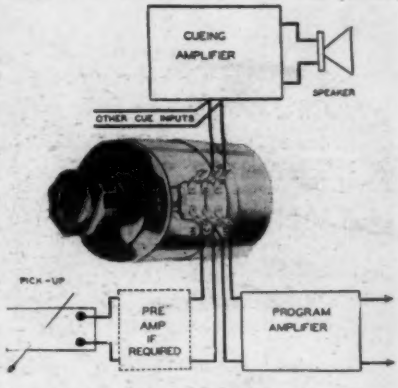
Acme ACME Electric



ranges are available. Interval variations are less than 2 percent in repeat cycle timing and less than 3 percent for as high as 10 percent variation in line voltage. Because of the characteristics of the resistor-capacitor elements the range is spread out in a logarithmic scale, making the dial dimensions wide in the shorter time periods.

Cue-Control Attenuators (34)

THE DAVEN CO., 191 Central Ave., Newark 4, N. J. A new line of attenuators with built-in cueing control transfers program material to



a cueing amplifier at the extreme attenuation position so that a program can be brought in smoothly without manipulation of additional cueing switches.

VHF Power Tube (35)

GENERAL ELECTRIC CO., Syracuse, N. Y. A new vhf power tube, type GL-5513, with a tube output ranging to 2 kw, has been designed for television and f-m applications under class B and class C conditions. The new tube can be operated up to 220 megacycles and it may be adapted to dielectric heating services employing the higher frequen-

SOON . . . THE NEW NATIONAL NC-173

The NC-173 is the wholly new product of months of post-war research, prompted by war-time advances in radio technique.

The new "Double Diode" noise limiter and the new AVC system are effective on both phone and CW. The voltage-regulated oscillator circuits are extremely stable. The frequency range includes the 6-meter amateur band. (0.54 to 31 and 48 to 56 MC.)

The NC-173 offers all the features you expect in a fine receiver. A glance at the illustration below will suggest the versatility of its adjustments and the handiness of its controls, but only a trial will prove its thoroughbred qualities. Study the advanced design of its 13-tube circuit, appraise its modern styling and challenge its performance with the toughest conditions that crowded amateur bands can offer.

Here is a receiver a man can be proud to own. See it at your dealer's within the next 30 days.

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COMPANY, INCORPORATED
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THE MOST DISTINCTIVE NAME IN RADIO COMMUNICATIONS

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POCKETSCOPE
MODEL S-II-A

by WATERMAN!

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A 3 INCH OSCILLOSCOPE for MEASURING AC and DC!

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AMPLIFIERS for vertical and horizontal deflection as well as intensity . . . Linear time sweep from 4-cycles to 50-kc with blanking of return trace . . . Sensitivity up to 100 mv/in . . . Fidelity up to 350-kc through amplifiers . . . Attenuators for AC and for DC . . . Push-pull amplifiers . . . Anti-astigmatic centering controls . . . Trace expansion for detail observations.

Chassis completely insulated from input circuits assures safety in industrial applications . . . Direct connections to deflecting plates and intensity grids from rear . . . Retractable light shield . . . Detachable graph screen . . . Handle . . . Functional layout of controls.

COMPLETELY PORTABLE!
8¾ lbs. . . . 11" x 7" x 5"

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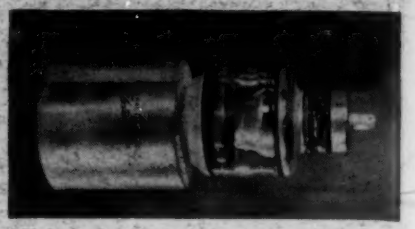
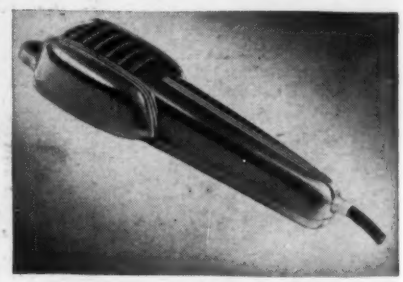


cies. When used as a grounded-grid amplifier in class C telegraphy, the tube has an output of over 2 kw with a power gain of ten. In class B video service under synchronizing peak conditions in a grounded-grid circuit, output exceeds 1 kw, with approximate power gain of 8.

Filament current of 32 amperes and filament voltage of 6.3 volts plus a grid-plate interelectrode capacitance of 8.7 μμf are among the electrical characteristics of the new tube. Maximum plate voltage rating under class C telegraphy conditions is 4,000 volts. For class B video operation the maximum plate voltage rating is 3,000 volts.

Hand Microphone (36)

THE TURNER CO., Cedar Rapids, Iowa. The model 20X crystal microphone withstands high humidity. Frequency response range is 50 to 7,000 cycles. Effective output level is 54 db below 1 volt per dyne per



square centimeter. A high-impedance unit, it can be used with any standard amplifier employing high-impedance input. Where cost is a factor, it is ideal for home recorders, public address, amateurs, paging, and call systems.

Synchronous Motor (37)

R. W. CRAMER CO., Centerbrook, Conn., the SX motor is primarily intended for applications that require a constant speed at a given frequency. It has a torque of 30 inch-ounces at 1 rpm. Power input is 2.7 watts at 115 or 230 volts, 60

It Had Us *Stumped!*

How to describe HOLLISTON Special Purpose Fabrics so that you will immediately recognize a use for them in *your* industry? That is the problem; and it has us stumped. Because these amazing fabrics have so many variable characteristics, so many potential uses. For instance, they can be flame-resistant and water-repellent. They can be impervious to mild acids, alkalies and solvents. They can be endowed with surprising dielectric and accoustic properties. They can be any or all of these things. What do they look like? They can be made to simulate almost any material you wish, for they can be fine as silk or coarse as burlap and either limp or stiff. Many HOLLISTON Special Purpose Fabrics are already serving industry daily. Most likely there is a HOLLISTON Fabric that will meet all your requirements. Find out today!

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Designed for

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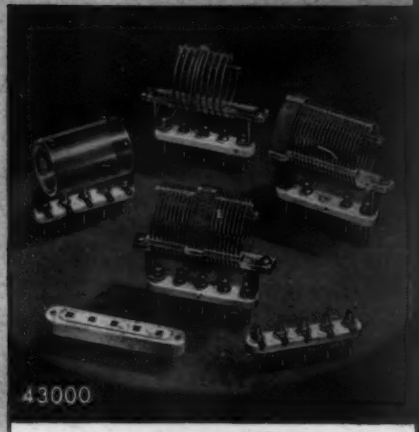
Application



The No. 43000

AIR WOUND INDUCTORS

and **ACCESSORIES**

Plug-in air wound inductors, coil forms, jack bars and sockets that have been "Designed for Application." The sockets are of the "straight line," type, facilitating symmetrical circuit arrangements and avoiding the undesirable bunching of leads, as when standard tube base socket-plug arrangements are used. Illustrated herewith are units from the small 75 watt or 43000 series. Two larger groups, the 44000 rated at 150 watts and the 42000 rated at 300 watts are also regularly available from your distributor of Millen radio products.

JAMES MILLEN MFG. CO., INC.

MAIN OFFICE AND FACTORY

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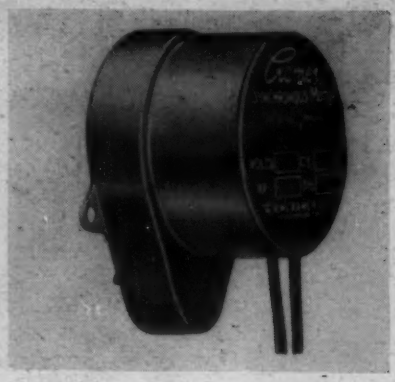
MASSACHUSETTS

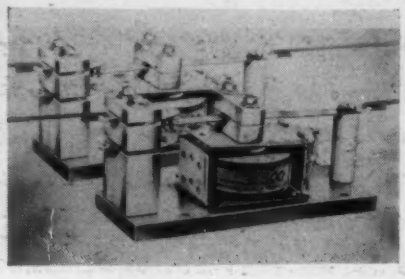
M



cycles. Rotor speed is 240 rpm at 60 cycles. Twenty-eight standard gear trains, ranging in speeds from 60 rpm to one revolution in 24 hours, make the unit adaptable to a variety of applications. Coils are easily removable for changes in voltage rating or field servicing. It is described completely in Bulletin No. 10.

Antenna Changeover (38)

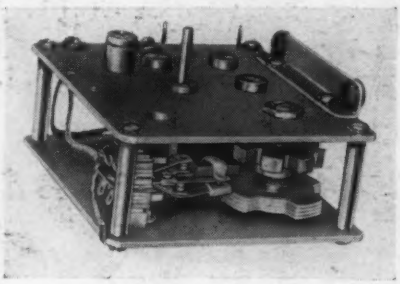
ADVANCE ELECTRIC AND RELAY CO., 1260 W. 2nd St., Los Angeles 26, Calif. Twin relays are available for switching of two-wire open trans-



mission lines. Since they can be placed any distance apart down to two inches they minimize discontinuities in line spacing.

Constant-Speed D-C Motor (39)

AMGLO CORP., 4234 Lincoln Ave., Chicago 18, Ill. An improved model of the constant-speed d-c motor is



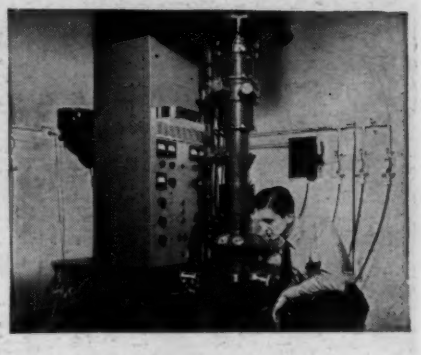
Silicone News

DC

DC 702 and DC 703

Silicone Diffusion Pump Fluids

- **STABLE TO AIR AND MOISTURE AT OPERATING TEMPERATURES**



- In electron microscopes
- In metal evaporator systems
- In producing vacuum tubes
- In dehydrating foods or pharmaceuticals

Never before have there been diffusion pump oils producing vacua up to 5×10^{-8} yet able to withstand atmospheric pressure at operating temperatures without appreciable decomposition.

DC 702 and DC 703 have those properties. Their vapor pressures are as low or lower than the best organic diffusion pump oils: recovery times after exposure to atmosphere at operating temperatures are much faster. Ultimate vacuum obtainable with DC 703 in a three-stage glass pump without cold traps is less than 5×10^{-8} mm.

DC 702 has a lower boiling point, operates against a higher forepressure and produces vacua in the range of organic diffusion pump oils.

Additional information about DC 702 and DC 703 is contained in pamphlet No. N 9-3.

SILICONE FLUIDS AS LIQUID DIELECTRICS—DC 200 Fluids are used in liquid filled condensers because of inherent stability, inertness to moisture, and a dielectric constant and power factor which change very little over a wide frequency spectrum. For additional data on DC Silicone Fluids write for catalog No. N 1-5.

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IN THE SALESROOM: One of the hallmarks of fine furniture and other household appointments is the decorative, straight-set, unburred head of the American Phillips Screw. More and more quality-minded buyers look for this distinctive feature—*both* for the sake of appearance, and as a *visible assurance* of sturdy construction and long service—their money's worth and then some! *Your* product should have this cost-cutting, sales-building advantage.

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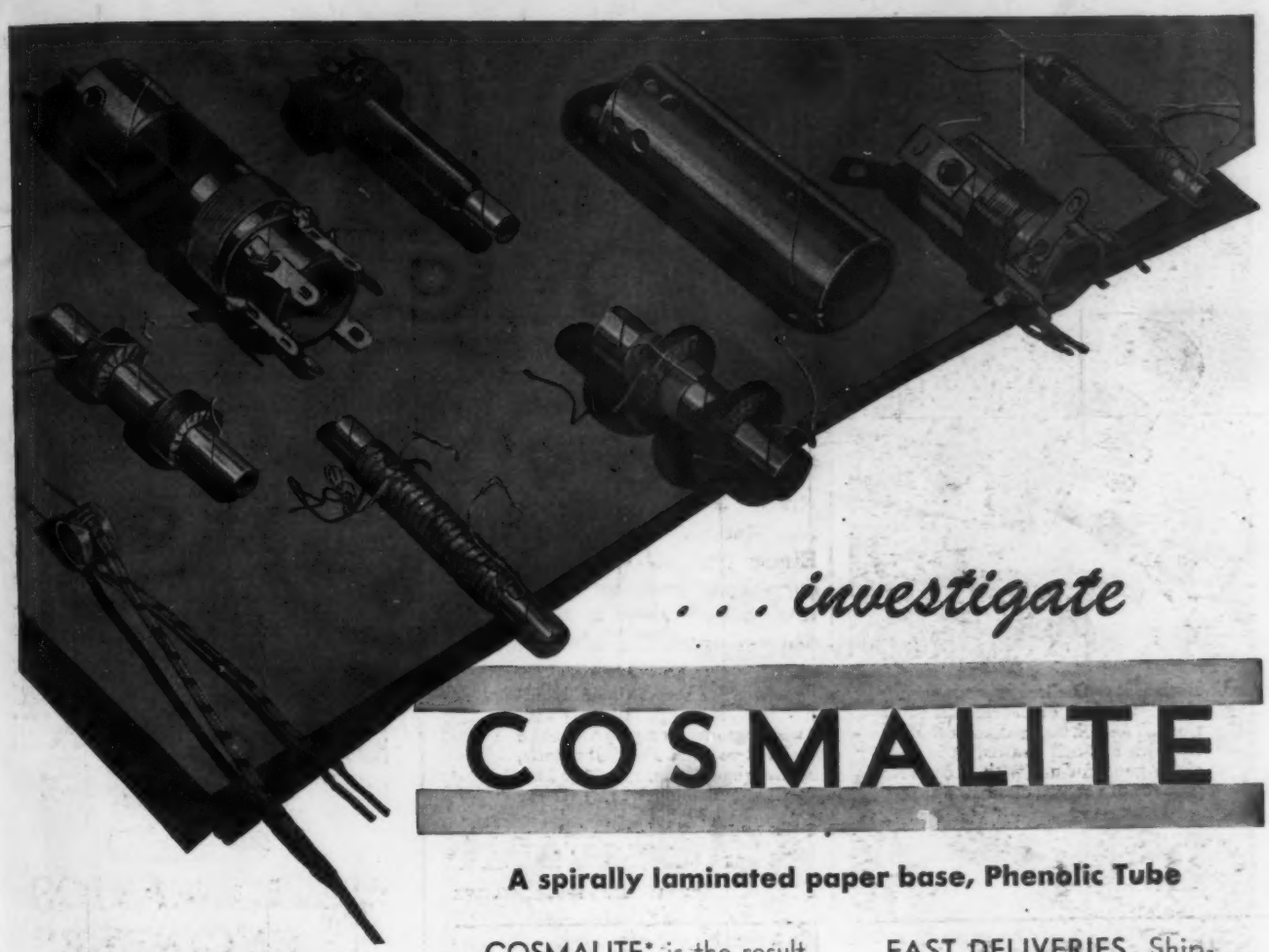

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SLF COSMALITE for Permeability Tuners available in wall thicknesses from .0065 to .0095.

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Made to your specifications
for diameter and resistance

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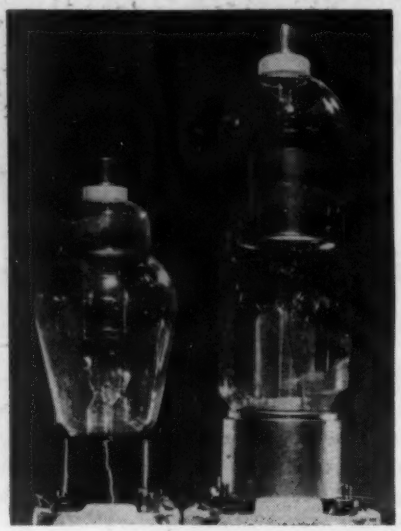
44 GOLD ST. NEW YORK

adapted to many uses formerly beyond the scope of the d-c field, particularly in industrial and commercial applications where synchronous units are required. The new model utilizes the principle of polarized magnetic drive of a vibrating reed, the nucleus of speed control under d-c power. Due to simplified design, the new motor is small enough to be held in the palm of the hand, though available for use at 3, 6, 12. 24, 32, or 110 volts.

Mercury-Vapor Rectifiers (40)

EITEL MCCULLOUGH, INC., 1018 San Mateo Ave., San Bruno, Calif. Eimac type 866A and 872A mercury-vapor rectifiers are directly interchangeable with types 866A/866 and 872A/872 of other manufacture. Type 866A operates with

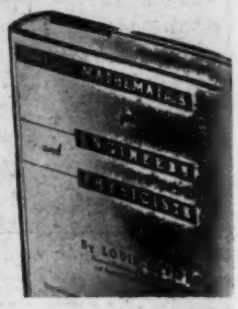


2.5 filament volts, peak inverse voltages as high as 10,000 volts, and a maximum average plate current of 0.25 ampere. The 872 has a 5-volt filament and carries a maximum peak inverse voltage rating of 10,000 volts and a maximum average current rating of 1.25 amperes.

Rotary Beam Turntable (41)

PREMAX PRODUCTS DIVISION of Chisolm-Ryder Co., Inc., Niagara Falls, N. Y. The Rotomount hand-operated mounting for rotary beam antenna arrays is formed of heavy sheet steel, spot-welded. The moving platform is supported on a 7-inch ball thrust bearing. A $\frac{3}{8}$-inch opening through the center of table and shaft provides space for leads. Cable

Practical
MATHEMATICS
for solving
engineering and
physics problems



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for ENGINEERS
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In this book, the mathematics of mechanical and electrical oscillations, electrical field theory, modern operational calculus, nonlinear oscillations, and potential field theory is clearly set forth. It provides you with a much-needed analysis of nonlinear oscillating systems and also with an enlightening discussion on modern methods of using matrix algebra to determine natural frequencies of oscillating systems and the systematic use of the operational or Laplace transform methods of solving differential equations. Every topic which forms the mathematical equipment of a scientific engineer or a physicist is covered completely.

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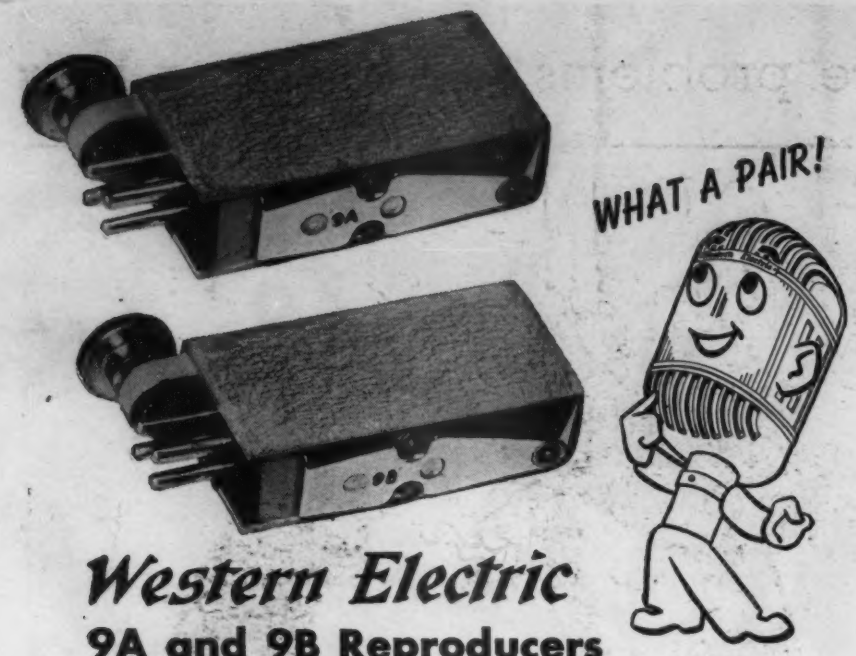


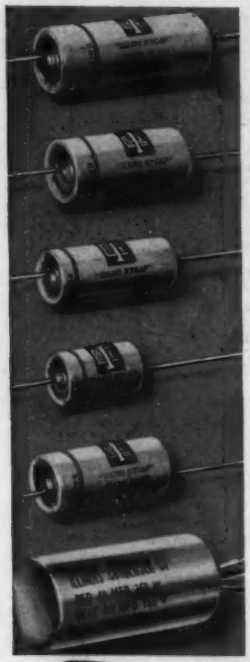
Western Electric

9A and 9B Reproducers

Both assure faithful reproduction of either vertical or lateral transcriptions. The 9A has a diamond stylus tip with a 2 mil radius. It is especially good for use with the narrow grooves of vertical cut discs. The 9B, with a sapphire stylus tip of 2½ mil radius, is especially good for use with the wider grooves employed in the lateral cut records. For full details, write Graybar Electric Co., 420 Lexington Ave., New York 17, N. Y.—or

ASK YOUR LOCAL **GraybaR**

BROADCAST REPRESENTATIVE



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ELECTROLYTIC CAPACITORS

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Our new plant is humming . . . turning out Capacitors of finest quality . . . serving our growing list of customers. At Illinois as always, the emphasis is not on *quantity* but on *quality* condensers of lightweight, compact construction endowed with ruggedness for long life. Latest and most modern production equipment, newest manufacturing techniques and the rigid control standards of our trained engineering staff is guarantee of the best in Capacitors.

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ILLINOIS CONDENSER CO.

1616 NORTH THROOP STREET • CHICAGO 22, ILL.

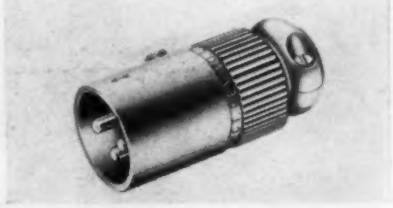
pulleys are dural, and the flexible steel cable furnished is so mounted that it can not come off the pulleys.

Signal Divider (42)

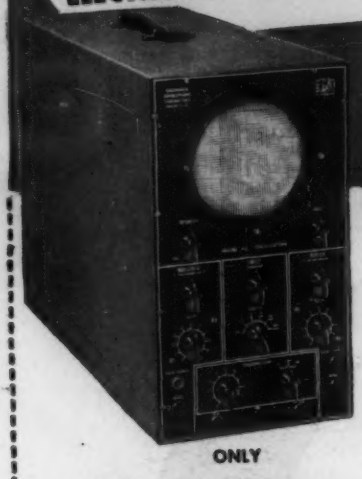
KEITHLEY INSTRUMENTS, 1508 Crawford Road, Cleveland 6, Ohio. The model 101 signal divider is an attenuator designed to provide the low-level input signals used in testing performance of high-gain amplifiers. Since most laboratory oscillators can be controlled from 0.1 volt to 15 volts, the divider extends the range down to about 10 microvolts. Frequency range is 0 to 200,000 cps and input admittance is approximately 11,000 ohms. Further details are available in bulletins issued by the manufacturer.

Steel-Shell Mike Connectors (43)

CANNON ELECTRIC, 3209 Humboldt St., Los Angeles 31, Calif. Two steel-shell plugs which will mate with the standard type XL zinc receptacles carry the additional designation SC. Overall length is slightly smaller than corresponding



NEW!
ELECTRONIC DEVELOPMENT 5" OSCILLOSCOPE



This new 5" Cathode Ray Oscilloscope is a precision instrument at an attractively low price, designed for practical application in laboratory research and production work. Sturdily built to stand up under continuous use, and ably engineered for accuracy, versatility and easy operation. Has wide frequency range, 10 cycles to 300 Kc. Deflection sensitivity, 1 volt RMS per inch. Sweep range, 10 cycles to 60 Kc. in four steps. For 110-120 volt, 50-60 cycle operation. In welded steel cabinet, with baked black wrinkle-finish; 8½" wide, 14½" high, 18½" deep. Instrument panel in black, with white designations; has removable calibrated plastic scale. Complete with tubes. *No. 84-376. Net Only.* **$99.50**

STOCK NO. 84-376 ONLY $99.50

Order from the Central Source for Everything in Radio and Electronics

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ALLIED RADIO CORP.
833 W. Jackson Blvd., Dept. 24-C-7, Chicago 7, Illinois

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PHENOL AND VULCANIZED
FIBRE FABRICATIONS

Close tolerances, any quantity—

Volume production and accuracy of BAER phenol and vulcanized fibre parts have resulted in their wide specification for every type of product and equipment. Expanded facilities now make it possible to offer BAER production to manufacturers needing quality parts to exact requirements. Write today for Bulletin 120.

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STAMPED
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DRILLED
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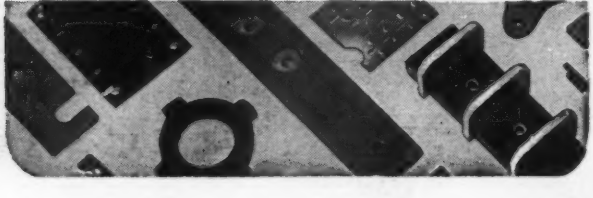
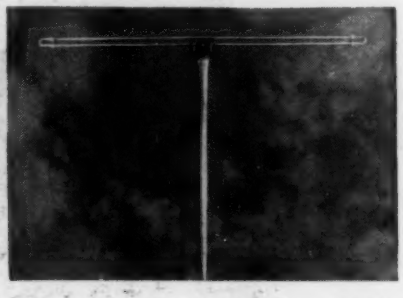
N. S. BAER COMPANY
Craftsmen in Fibre Fabrication
7-11 MONTGOMERY ST. • HILLSIDE N. J.



zinc-plug types. The socket insert assembly carries the latch-lock device. The construction of the shell makes it adaptable to other uses than sound, providing the amperage requirements of the circuits do not exceed the 15-ampere rating of the three contacts, and the minimum flashover voltage is not more than 1,500 volts (250 v working voltage) under normal conditions. Bulletin XL-SC2 will be sent free upon request.

F-M Antenna (44)

STROMBERG-CARLSON CO., Rochester 3, N. Y. The DynaTenna, designed for use on both the 44 to 50 and the 88 to 108 mc f-m broadcast band, is adjustable and can be peaked to the particular frequency of any individual station for maximum response. The U-tube sections of the antenna are designed on the principle of the slide trombone, are easily adjusted and locked in place, and are calibrated in frequency graduations on both sides. The upper side functions as a quarter-wave folded dipole to cover the lower frequencies in the 44 to 50 mc band. The lower side operates as a half-wave folded dipole in the higher frequencies of the 88 to 108 mc band. A flexible construction permits erection for vertical as well as horizontal polarization. The antenna is supplied with 60 feet of low-loss, 300-ohm, plastic-covered lead-in wire recently standardized by the industry.



VTVM Kit (45)

FREDERIC D. SCHOTTLAND, 82-62 Grenfell Ave., Kew Gardens, N. Y. Only screwdriver and soldering copper are named as requisites to assemble and wire a complete vacuum-tube voltmeter that is sold in kit form. Full range is 0.2 to

try this for Size!

where Space is a limiting factor

CONSIDER GENERAL ELECTRIC SELENIUM RECTIFIERS

Important savings in space and weight are realized when you design General Electric Selenium Rectifiers into electronic equipment. They'll give you more direct current per cubic inch, more per pound, than alternate types. General Electric offers a wide selection of capacities and sizes, from the mighty midget pictured above which delivers 4 volts at 0.1 milliampere to single stacks rated at 110 volts, 4 amperes.

Whatever your requirements, General Electric Selenium Rectifiers pack a lot of punch where space is at a premium. They withstand extreme variations in ambient temperature, humidity, and atmospheric pressure. You can depend upon them for long, faithful service in series, parallel, or series-parallel arrangement.

For a booklet of facts and figures, write direct to Section A-18-331, Appliance and Merchandise Department, General Electric Company, Bridgeport 2, Connecticut.

GENERAL ELECTRIC

TURN TO PLAX FOR PLASTICS

Plax supplies materials below in forms as checked. They are available in a full color range.	SHEET	ROD	TUBE	FIBER	BLOWN WARE	MACHINED PARTS
Cellulose Acetate	✓	✓	✓	✓	✓	✓
Cellulose Acetate Butyrate	✓	✓	✓	✓	✓	✓
Ethyl Cellulose	✓	✓	✓	✓	✓	
Methacrylate		✓	✓	✓		✓
Polyethylene	✓	✓	✓	✓	✓	✓
Polystyrene	✓	✓	✓	✓	✓	✓

Vinyls, Cerex, Styraloy, Plexene, and certain special copolymers are also available from Plax, as are special extruded shapes in most materials.

Plax is a leading source of plastics in sheet, rod, tube, and fiber blown forms — also machined parts. This ability of Plax to supply a wide variety of plastics in a wide variety of forms simplifies your task of obtaining the best type of material for your product. Plax offers you many unique plastics developments, such as the tough and flexible Polyflex* Sheet, Laminated Polyflex, and Polyflex fiber forms of polystyrene.

At your disposal, too, is expert advice on plastics applications by Plax engineers and a comprehensive library of technical data (see list of literature). These advantages point convincingly to the wisdom of turning to Plax for your plastics requirements — for both materials and the guidance you may need in their application.

*T.M. Reg. U.S. Pat. Off.

WRITE FOR THIS POLYSTYRENE DATA

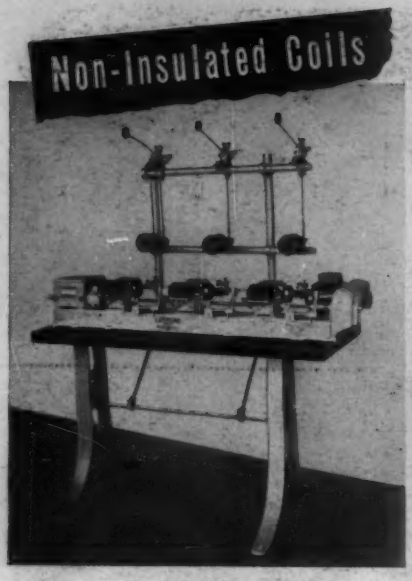
How to Machine Plax Polystyrene Products.
How to Use Coolants with Plax Polystyrene Products.
How to Cement Plax Polystyrene Products.
How to Polish Plax Polystyrene Products.
Notes on Design and Assembly of Plax Polystyrene Products.
Die-cut Parts from Plax Polystyrene.
How to Form Plax Polystyrene Rod.

AND THIS PRODUCT INFORMATION

Data Sheets on Plax Cellulose Acetate, Cellulose Acetate Butyrate, Methacrylate, Polyethylene, Polystyrene and Ethyl Cellulose Products.
Article on Plax's Blown Products.
New special plastic shapes by Plax.

PLAX
FOR PLASTICS
NOT SUBSTITUTES···IMPROVEMENTS

133 WALNUT STREET ★ HARTFORD 5, CONNECTICUT



MORE PER HOUR

because operator tends three or more heads

On the No. 102 Universal Coil Winding Machine, machine production is synchronized with the time required to perform manual operations.

One operator supervises several winding heads (two to six) simultaneously, and winding is so scheduled that certain heads are producing while manual operations are performed on other heads.

Winds on forms or directly on cores or bobbins . . . each head controlled by electric counter which automatically disengages clutch upon coil completion . . . readily adjustable mechanism for governing wire-layer length, eliminating extra cams . . . traverse changes easily made.

Write for Bulletin 102. Universal Winding Company, P. O. Box 1605, Providence 1, R. I.

For Winding Coils in Quantity, Automatically, Accurately—Use . . .

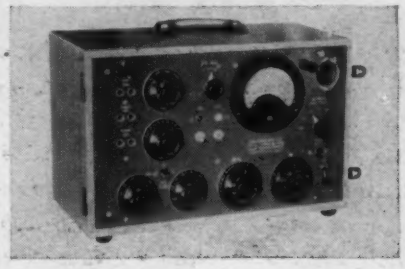
239 6-2

UNIVERSAL WINDING MACHINES

300 volts, 20 cycles to 200 megacycles. Input capacitance is less than 7 μμf at all frequencies.

Transmission Measuring Set (46)

TECH LABORATORIES, INC., 337 Central Ave., Jersey City 7, N. J. A completely selfcontained, a-c operated measuring set combines the



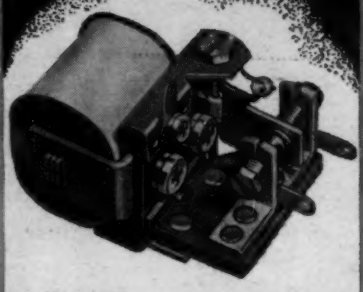
functions of an accurate vacuum-tube voltmeter, fixed-frequency audio oscillator with four settings, and precision attenuator. Designed for broadcasters, it measures gain up to 80 db and losses down to 60 db. The precision attenuator is flat to 20 kilocycles.

Literature

(47)
Wiring Aid. Star Expansion Bolt Co., 147 Cedar St., New York 6, N. Y. A miniature socket wiring plug and miniature tube pin straightener used in production of small electronic equipment have been pictured in a small brochure.

(48)
Servo Unit. W. C. Robinette Co., 802 Fair Oaks Ave., South Pasa-

REQUIRE *Relays?*



SIGMA

SENSITIVE RELAYS

have proven themselves in countless applications:

- ✔ Temperature Control
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- ✔ Telephone Dialing
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. . . and many others.

Specify **SIGMA!**

SIGMA'S specialty is the combination of a fine relay and an unusually thorough approach to your specific application problem.

SIGMA standard relays are available with various enclosures including fixed mountings, 5-pin, and octal male plug bases.

New relays are being developed for special purposes. Send your requirements to SIGMA for dependable relay recommendations.

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Sensitive **RELAYS**

62 Ceylon St., Boston 21, Mass.

MODEL 430 SERIES
Matched Portables

Universal favorites for electrical testing and maintenance . . . compact and extremely rugged, high-visibility mirror scales and knife edge pointers, accuracy and dependability in the WESTON tradition . . . all at relatively low initial cost. Available for all AC and DC requirements. See your nearest WESTON representative or write direct . . . Weston Electrical Instrument Corporation, 618 Frelinghuysen Avenue, Newark 5, New Jersey.

Weston *Instruments*

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SEATTLE • ST. LOUIS • SYRACUSE • IN CANADA, NORTHERN ELECTRIC CO., LTD., POWERLITE DEVICES, LTD.

BRADLEY

PHOTO ELECTRIC CELLS

Turn Light Into Current

Bradley's Luxtron* photocells convert light into electrical current. No additional source of voltage is required. Light-actuated Bradley cells provide control devices that give the longest life and need the least maintenance.

In addition to the housed model shown, with its plug-in contacts, Bradley also offers tube socket, nut-and-bolt types and pigtail contact mountings.

The shapes of Luxtron photocells vary from circles to squares, with every in-between shape desired. Their sizes range from very small to the largest required.

*T. M. Reg. U. S. Pat. Off.

Illustrated literature, available on request, shows more models of Bradley photocells, plus a line of copper oxide and selenium rectifiers. Write for "The Bradley Line."

BRADLEY LABORATORIES, INC.

82 Meadow St. New Haven 10, Conn.

dena, Calif. The Motron servo unit model 61A is a packaged continuous balance control system of great sensitivity that can be applied to automatic control or regulation of equipment. An illustrated sheet H-26 can be had from the company.

(49)

Insulators. Centralab, 900 E Keefe Ave., Milwaukee 1, Wis. A new catalog includes 28 pages of information on standards, design criteria, body characteristics and common shapes of various cearmic insulators. Included is data on metallized ceramics and printed circuits.

(50)

Tube Socket Guide. E. F. Johnson Co., Waseca, Minn. The 1946 edition of the tube socket guide is in effect a detailed catalog of the company's sockets and connectors together with applications and illustrations.

(51)

Tube Data. Amperex Electronic Corp., 25 Washington St., Brooklyn 1, N. Y. An 8-page booklet containing tube data reference tables describes the complete line of transmitting, rectifying and industrial tubes manufactured by the company.

(52)

Portable Rectifier. W. Green Electric Co., Inc., 130 Cedar St., New York, N. Y. The model 725S1C portable rectifier with output of 25 amperes from 0 to 6 volts is completely described in literature available from the manufacturer.

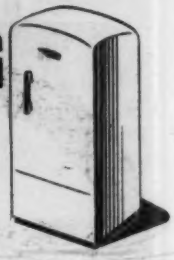
(53)

Ball Bearings. New Hampshire Ball Bearings, Inc., 2 Main St., Peterborough, N. H. Bulletin 47 describes a new line of small ball bearings suitable for instrument and small mechanisms use.

(54)

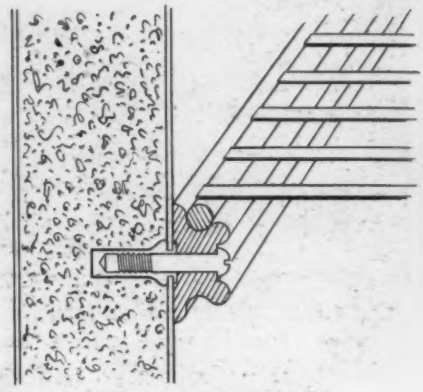
Bulletins. Sylvania Electric Products, Inc., 500 Fifth Ave., New York 18, N. Y. Data sheets on several of the company's new products have just come off the press. Bulletin EC-24 describes the use of

FASTENING PROBLEM:



To hold refrigerator shelf, attach extruded plastic strip to interior wall. Wall must be air-tight, porcelainized metal must not be chipped.

Here's how **RIVNUTS** *solved it...*



8-32 thread blind-end aluminum Rivnuts were inserted through holes in porcelainized metal into insulating material. Operated from one side only, simple header tool upset them. The plastic strip was placed—screw attachments entered into holes and tightened in clean threaded Rivnuts. Head of Rivnut kept wall air-tight, did not chip metal sheet. Installation time and money were saved because wall section didn't require removal . . . maintenance was made easier. Perhaps this application might point the way to the solution of your fastening problem.

FREE "RIVNUT DATA BOOK"

Illustrated Rivnut facts at your fingertips. How to install, uses, types, test data, tools. Write today for your free copy to The B. F. Goodrich Company, Dept. E-37, Akron, Ohio.

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RIVNUTS

It's a rivet—It's a nutplate

ANOTHER
SPECIAL BY
PROGRESSIVE
QUALITY PROMCO BRAND
BLUE-PRINT
ACTUAL SIZE
ENLARGED FOR DETAIL
CATALOG SHOWS DOZENS MORE
Special heads, threads and finishes on any metal or alloy adapted to cold upset. Weekly output: 25,000,000 pieces. Many specials, suggesting production savings for you, illustrated in latest catalog. Includes weights per 1M standard pieces, decimal equivs. of fractions, other purchasing and engineering helps. Write for Catalog 18.
The PROGRESSIVE MFG. CO.
50 NORWOOD ST. TORRINGTON, CONN.

New . . . Improved
ATTENUATORS
by TECH LABS
TYPE 800 and 900
Type 800
Type 900
"New Times—New Modes", says old proverb. These new attenuators were born to meet new war-created demands. They represent a new medium frame size: Type 800 (2¼" dia.) and a larger size: Type 900 (3" dia.). The Type 800 is supplied as potentiometer, rheostat, ladder and T-pad up to 20 steps. The larger size Type 900 is similarly furnished with up to 45 steps. Write for new bulletin.
TECH LABORATORIES, INC.
Manufacturers of Precision Electrical Resistance Instruments
337 CENTRAL AVE. • JERSEY CITY 7, N. J.

the hydrogen thyratron type 4C35. Bulletin EC-23 gives further information on the type R4330 electronic flash tube. Germanium and silicon crystals are covered in bulletins EB-6 and EC-22B.

(55)
Marine Radiotelephone. Radiomarine Corp. of America, 75 Varick St., New York 13, N. Y. A new two-color folder details the features of a 75-watt radiotelephone transmitter-receiver combination, model ET-8012-D. The transmitter has ten crystal-controlled channels and a nine-tube receiver is used for two-way communication.

(56)
Phototube. Radio Corp. of America, Harrison, N. J. A high-vacuum, blue-sensitive phototube, type 1P42, recently announced, is completely analyzed in a leaflet now available. The tube has been designed particularly for control purposes in applications where space limitation is of prime consideration, the maximum diameter of the tube being ¼ inch.

(57)
Vibration Pickup. The MB Mfg. Co., New Haven, Conn. A four-page, two-color leaflet pictures all aspects of an interesting magnetic pickup used for industrial vibration analysis.

(58)
Audio Components. Burnell and Co., 10-12 Van Cortlandt Ave., East, Bronx 58, N. Y. High-Q toroidal coils, equalizers and attenuation filters are described in a four-page two-color catalog recently issued.

(59)
Resistor Bulletin Resistors, Inc., 2241 South Indiana Ave., Chicago 16, Ill. A new catalog bulletin of resistor data on the full line of the company's resistors and windings is now available. Write for bulletin 87.

(60)
Graphic Pyrometer, Leeds and Northrup Co., 4934 Stenton Ave.,

FOR ROUTINE MEASUREMENTS of

- INDUCTANCE
- CAPACITANCE
- RESISTANCE

TYPE 650-A
Impedance Bridge
$220

NO laboratory, in which any electrical equipment is used, is complete without this bridge. Completely self-contained, portable, and accurate enough for most routine measurements, the popular Type 650-A Impedance Bridge is always set up and ready to use. With it you can measure these basic quantities over these very wide ranges—**INDUCTANCE:** 1 microhenry to 100 henrys; **CAPACITANCE:** 1 micromicrofarad to 100 microfarads; **RESISTANCE:** 1 milliohm to 1 megohm. In addition it measures **DISSIPATION FACTOR** (R/X) from .002 to 1, and **STORAGE FACTOR** (X/R or Q) from .02 to 1,000.

The bridge includes built-in standards, batteries, a 1,000-cycle tone source for a-c measurements, a zero-center galvanometer null indicator for dc and terminals for a headset for 1,000-cycle null detection.

Provision is made for use of an external generator for measurements over a wide range from a few cycles to 10 kilocycles.

Direct-reading dials add greatly to the ease and rapidity with which measurements can be made with this universal bridge.

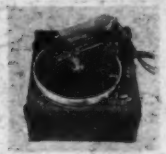
WRITE FOR COMPLETE INFORMATION

GENERAL RADIO COMPANY Cambridge 39 Massachusetts

90 West St., New York 6 — 920 S. Michigan Ave., Chicago 5 — 950 N. Highland Ave., Los Angeles 38

HARVEY HAS PRESTO

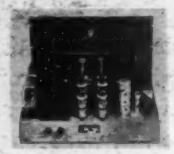
The Presto 6-N recording turntable is offered as a replacement unit for the Presto 6-D, hundreds of which are now in operation in broadcasting stations and studios.



The overhead-cutting mechanism has been redesigned and is removable as a unit to store in a pocket inside the case for safer transportation. The cutting head weight rests entirely on two slider bars. Mechanical vibration is reduced by the use of a heavier turntable base. Head mounting is integral with base and new design permits quick alignment of mechanism with turntable.

The 6-N is available in three forms:

Chassis only	$690
In 1-B portable case	735
In 4-A floor cabinet	821



PRESTO 88-A AMPLIFIER

The 88-A complements not only the 6-N recorder, but any recording channel. It has three calibrated response curves, No. 1, flat from 50 to 17,000 cps.; No. 2, complements NBC Orthacoustic playback system; No. 3, complements standard high fidelity playback systems. Gain 85 db. Power output 50 watts. Distortion less than 1½%..... $345

Harvey carries a complete line of Presto equipment in stock at all times for immediate delivery.

Note: All prices quoted FOB New York and subject to change without notice.

Telephone: hrc LO. 3-1800

HARVEY RADIO COMPANY INC.

103 West 43rd St., New York 18, N. Y.

Philadelphia 44, Pa. Catalog ND46(1) illustrates the Speedomax type G recorder primarily designed for pyrometers. Single or multiple temperatures can be recorded on the same sheet.

(61)

Transmitter Parts. E. F. Johnson Co., Waseca, Minn. The capacitanced general products catalog No. 969 covers variable transmitting capacitors, inductors, tube sockets, and other items as well as new lines such as multiwire connectors, dial lights, and tip plugs.

(62)

Synthetic Rubber Insulation. Simplex Wire and Cable Co., 79 Sidney St., Cambridge 39, Mass. A 12-page slick-paper report to industry on synthetic rubber insulations used by the company.

(63)

Components Catalog. Cambridge Thermionic Corp., 445 Concord Ave., Cambridge 38, Mass., has just issued a new 20-page tabbed-section catalog with specification sheets giving data on all its products except crystals. Copies are available from Dept. 4.

(64)

Receiving Tubes. Radio Corp. of America, Harrison, N. J. A new 16-page booklet titled "Receiving tubes for television, f-m and standard broadcasting" (form 1275-C) charts characteristics and socket connections. Tubes are classified in various convenient ways and the booklet sells for 10c.

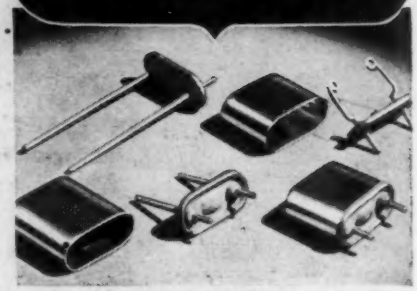
(65)

Radio and Industrial Tubes. Radio Corp. of America, Harrison, N. J. A 16-page booklet entitled "Power and gas tubes for radio and for industry" (form PG-101) has been compiled so as to present the subject information with clarity and simplicity. Copies can be obtained at 10c. each.

(66)

Recording Materials. Eastman Kodak Co., 343 State St., Rochester 4, N. Y. A new 44-page booklet describing photographic recording

It Will Pay You to Adapt This HERMETICALLY SEALED 2 TERMINAL CRYSTAL HOLDER...



FOR USES SUCH AS: Hermetically sealed thermostat housings, rectifiers, relays, coils, heaters, etc.

WHY: Saves space and weight . . . impervious to all elements . . . can undergo variations in temperature without loss of resistance . . . no condensation within.

DIMENSIONS: Approximately ⅜" x ¾" oval; cover ½" or ¾" in height.

FEATURES: Made of glass and metal for unrestricted use. Terminals available in any height, inside and out. May be had with special spring mounting on the inside. Base hot tin coated. Assembly can be crimped or soldered with simple tools. Resistance over 10,000 megohms. Cover — nickel silver, brass or steel. Over 1½ million pieces built in 1946.

WRITE: Submit your requirements for samples and estimates.

HERMETIC SEAL PRODUCTS COMPANY

414-418 MORRIS AVE., NEWARK 3, N. J.

materials for use with cathode-ray tube oscillographs, galvanometer oscillographs, and similar instruments is obtainable on request. Equipment and technique are discussed, and a table of relative speeds of films and papers is provided.

(67)

Precision Testing Equipment. General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass. Catalog K, Fifth Edition, has recently been mailed out. It describes the complete line of frequency standards, signal generators, monitors, and components. Included is a new price list.

(68)

Low-Loss Leadin. General Electric Co., Syracuse, N. Y. A single-sheet catalog bulletin tots up the characteristics of two types of 300-ohm parallel twin-conductor cable for television and f-m and the somewhat similar 100-ohm r-f cable.

(69)

Vacuum Tube Voltmeter. Reiner Electronics Co., Inc., 152 West 25th St., New York 1, N. Y. A single sheet tells about the Model 451 vacuum-tube voltmeter and the Model 101 amplifier that can be used to increase its sensitivity a hundredfold.

(70)

Volume Control Index. Clarostat Mfg. Co., Inc., 130 Clinton St., Brooklyn 2, N. Y. The volume control cross-index guide is a collection of cards printed on both sides with the complete cross-index of corresponding type numbers of four leading volume-control manufacturers, arranged numerically. The guide is free from distributors or by writing the company.

Tube Registry

Tube Types Registered by RMA (Starting Oct. 1946)

Type 5558

Half-wave mercury rectifier, heater type, heating time 5 min.; tempera-

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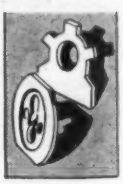

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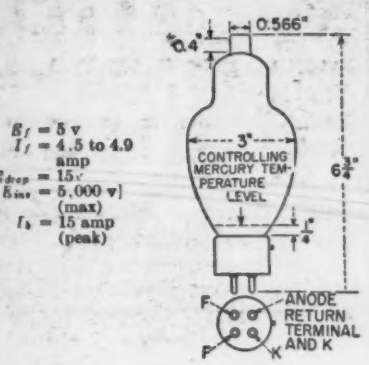
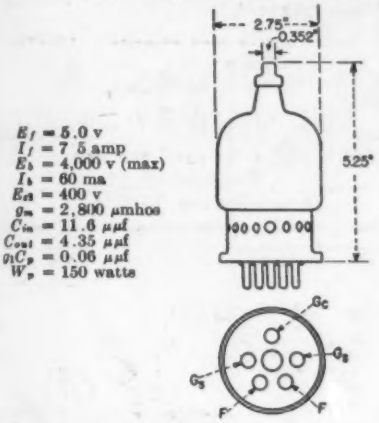


ture range, +30 to +60 F; frequency, 150 cycles, basing 3W.

Type 4D23

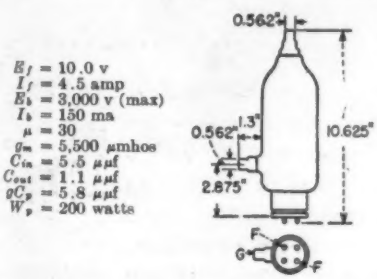
Tetrode power amplifier/oscillator, filament type, special glass enve-



lope; maximum ratings in Class C operation up to 120 mc; basing 5BK.

Type 4C32

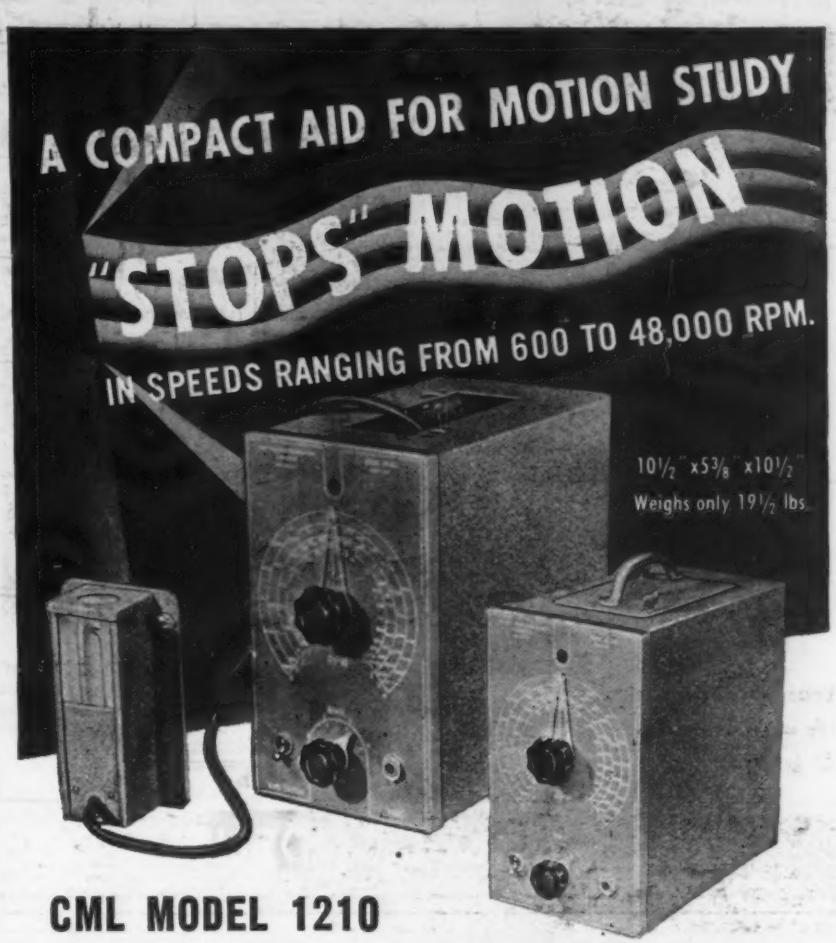
Triode power amplifier/oscillator,



filament type, special glass envelope, maximum ratings up to 60 mc.

Type 5559

Triode thyratron, heater type, heating time 5 minutes; ionization time,



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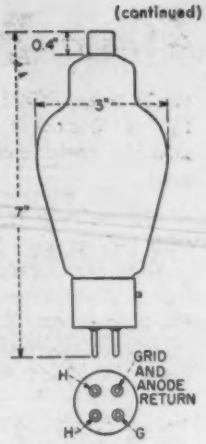
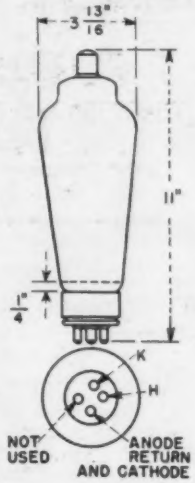


E_f = 5 v
I_f = 4.5 to 4.9 amp
E_{drop} = 16 v
E_b = 1,000 v
E_{ct} = 0
$E_{control}$ = − 6.5 v
E_{inv} = 1,000 v (max)
E_{fwd} = 1,000 v (max)
E_c = − 500 v
I_b = 200 amp (0.1 sec surge)
I_c = 0.25 amp
C_{in} = 10 $\mu\mu$f
gC_p = 2.5 $\mu\mu$f

10 microseconds; deionization time, 1 millisecond; basing 4BL.

Type 5561

Half-wave mercury rectifier, heater type; heating time 5 min; tempera-

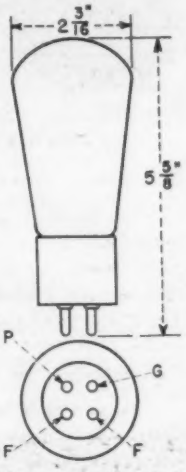


E_f = 5 v
I_f = 10 to 10.75 amp
E_{drop} = 15 v
E_{inv} = 10,000 v (max)
I_b = 80 amp (0.1 sec surge)

ture range, −25 to +50 C; frequency 150 cycles.

Type 5556

Triode power amplifier/oscillator,



E_f = 4.5 v
I_f = 1.1 amp
E_b = 350 v
I_b = 19 ma
E_c = − 20 v
μ = 8.5
g_m = 1,330
C_{in} = 2.3 $\mu\mu$f
C_{out} = 3.1 $\mu\mu$f
gC_p = 7.7 $\mu\mu$f
I_b = 40 ma (max)
W_p = 7.5 watts

filament type, maximum ratings to 6 mc, basing 4AX.

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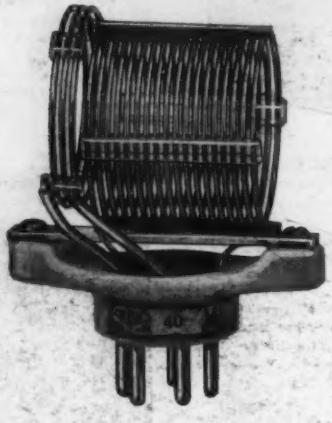

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NEWS OF THE INDUSTRY

(continued from p 154)

slapped on everything having to do with nuclear physics.

Among the important items in this group of documents are papers by Dr. Enrico Fermi on "Elementary Theory of the Chain-Reacting Pile," Dr. H. Fridell on "Atomic Energy and Cancer," Dr. D. E. Hull on "The Counting Method of Isotopic Analysis of Uranium," Dr. A. C. Klein on "Atomic Bomb Engineering," and Dr. C. R. McCullough and Dr. H. E. Hawk on "The Daniels Atomic Power Plant."

In general, the papers report on a wide variety of technical discoveries in mathematical, physical, chemical, engineering, and medical fields. Most are of extremely high scientific level, prepared by individual scientists who have worked or are working on the atomic project, not official Atomic Energy Commission documents.

Atomic energy papers are declassified at the Clinton Laboratories, Oak Ridge, Tenn., by the Manhattan Project Editorial Advisory Board. This board is composed of a group of civilian scientists who act as a voluntary review committee to advise the officials of the Manhattan District which papers can safely be made public, and which should await completion of arrangements for the international control of atomic energy before they can be released.

After the Board has cleared a document, Manhattan District officials review the decision and in the great majority of cases approve the declassification and send the paper to the main office of the Atomic Energy Commission in Washington. From there it is transmitted to OTS for actual release and dissemination.

Many of the papers have already appeared in various journals, and others have been released for general information, for use in lectures on nuclear physics, and for guidance in preparing discussions of atomic energy.

Abstracts of all 270 papers, with microfilm and photostat prices of each, have been prepared in the form of a lithographed report on Nuclear Physics by the Office of Technical Services, Department of Commerce, Washington 25, D. C. A rough breakdown gives 8 papers on

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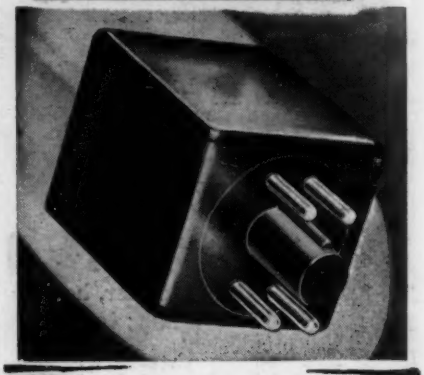
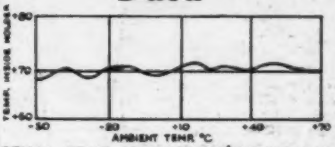


Performance Data



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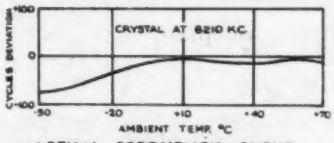
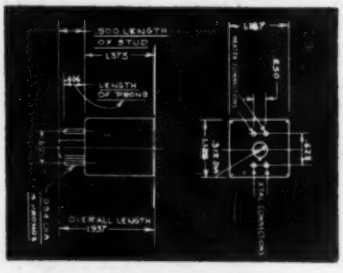


ACTUAL FREQUENCY CURVE



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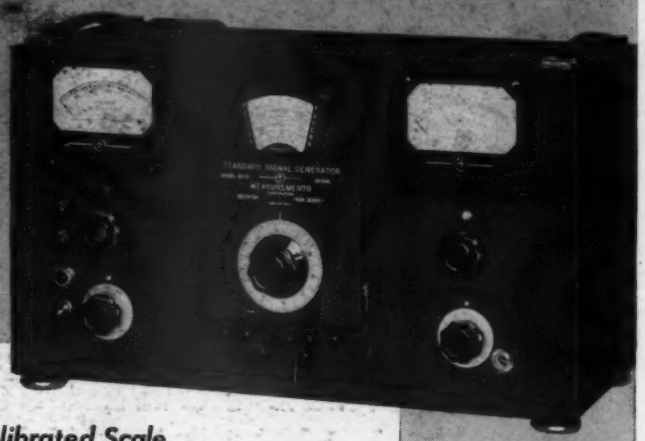

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OUTPUT IMPEDANCE: 5 ohms to .2 volt, rising to 15 ohms at 2.2 volts.

MODULATION: From zero to 100%. 400 cycles, 1000 cycles and provision for external modulation. Built-in, low distortion modulating amplifier.

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WEIGHT: Approximately 50 lbs.

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Phase Sequence Indicators

Television and FM Test Equipment

electronic counter circuits, 2 on electron tubes, 12 on nuclear machines such as cyclotrons, 6 on ionization gages and G-M tubes, and 30 on miscellaneous electron tube circuits that were considered in connection with the atomic energy projects. Representative abstracts of some of these electronic papers follow.

PB 49548, ALLEN, J. S., Characteristics of metal type electron-multiplier tube, (Manhattan Engineer District LA Rept 65, Series C; MDDC Rept 275) Mar 1944, 12 p. Price: Microfilm—$1.00—Photostat—$1.00

Scientific paper released for general information Sept. 12, 1946. An electron multiplier tube of the electrostatically focused type enclosed in a metal shell has been developed. The metal construction permits the use of copper gaskets and the outgassing of the tube by external heating. When a narrow beam of Po alpha-particles hits the first electrode the tube will count every alpha falling upon the sensitive surface. Approximately 5×10^6 electrons reach the final collector for each alpha incident upon the first electrode. The tube may be used as a pulsed detector by varying the potential of one of the electrodes with respect to the others.

Both static and dynamic tests were made. A square wave of 150-volts amplitude will turn the tube on and off. A radium source surrounded by 5 cm of Pb was placed near the multiplier tube. The counting rate was about 10^{-4} times the number of photons striking the first electrode. Graphs and a circuit diagram are included.

PB 52819, CHADWICK, S. R., Alpha counters as used in radioassay of Plutonium, (Manhattan Engineer District LADC Rept 272; MDDC Rept 454) Jan 1946, 58 p. Price: Microfilm—$2.00—Photostat—$4.00

Scientific paper released for general information. A description of the amplifiers, scalers, and power supplies used with the air and nitrogen chambers is given. Circuit diagrams and shop drawings of the chambers are included in the appendix.

PB 52802, FRISCH, O. R., Note on a use of delay lines in counter pulse amplifiers, (Manhattan Engineer District, LA Rept 107; MDDC Rept 238) Jul 1944, 5 p. Price: Microfilm—$1.00—Photostat—$1.00

Scientific paper released for general information August 22, 1946. A delay line is used to bring a pulse disturbance quickly back to zero, thus permitting more rapid counting than usual and helping to eliminate low-frequency interference.

PB 52717, GHIORSE, A. and others, The multi-channel pulse analyzer, (MDDC Rept 23) n.d. 27 p. Price: Microfilm—$1.00—Photostat—$2.00

The pulse analyzer consists of an ionization chamber and electronic units which make it possible to record the energy distribution of alpha disintegrations in a radio-active sample. In particular it is used to measure the amounts and determine the nature of alpha disintegrations in a mixture of isotopes. Description and circuit diagrams of the equipment are included in this paper released for general information through Manhattan Engineer District June 14, 1946.

PB 52719, HIGINBOTHAM, W., Higinbotham scale of 64, mark 5, model 3 (MDDC Rept 26) Dec 1945, 2 p. Price: Microfilm—$1.00—Photostat—$1.00

This scaling instrument is built for use with a self-quenching Geiger-Mueller tube. The scale of 64 is of the Eccles-Jordan type as modified by Higinbotham. The scaler will operate on evenly spaced pulses to a speed of at least 150,000 counts per second. A circuit diagram accompanies the description, which is released for general information through the Manhattan Engineer District.

PB 52739, JAFFEY, A. H. and others, A manual on the measurement of radioactivity (MDDC Rept 388) Aug 1944, 49 p. Price: Microfilm—$1.00—Photostat—$4.00

Scientific paper released for general information, October 16, 1946. This manual was written as an introduction to radioactivity measurements for chemists and others who were unfamiliar with this field. Its aim is to provide fairly explicit operating instructions together with the minimum background necessary for intelligent use of the instruments and interpretation of results. It is restricted to instruments and techniques for the development of processes for the chemical engineering scale separation of

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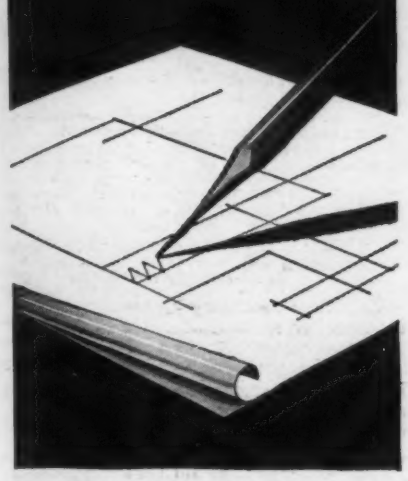

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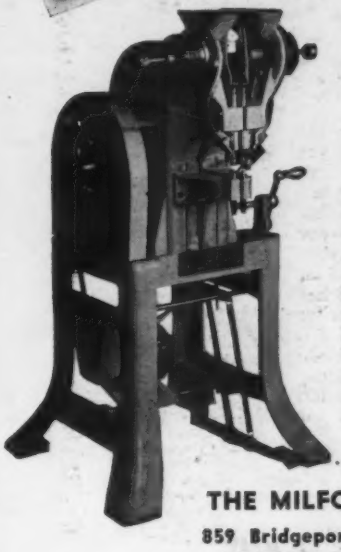

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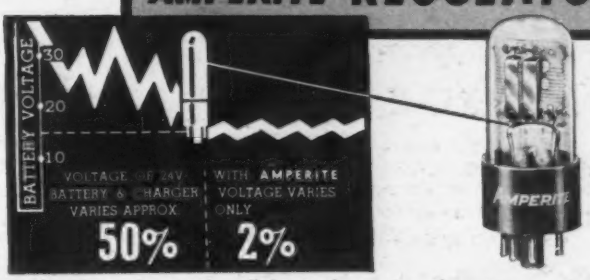

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plutonium from uranium and fission product activities. The manual has three sections: (1) Alpha counting; (2) measurement of beta and gamma radiation; and (3) statistics and counting. Diagrams and graphs are included. A foreword written in 1946 indicates which of the material is now obsolete and what new methods and instruments are in general use. It also contains a list of references.

PB 49561, KATCOFF, SEYMOUR, Sweeping of radioactive gases from a homogenous pile. (Manhattan Engineer District LADC Rept 215; MDDC Rept 293) Apr 1946. 23 p. Price: Microfilm—$1.00—Photostat—$2.00

Scientific paper released for general information September 11, 1946. The radioactive fission-product gases produced in a homogeneous pile were blown by a stream of air through a long tube along whose axis was a negatively charged wire. The various gases deposited their solid radioactive daughters upon the wire in a manner proportional to their half-lives. By cutting the wire into sections and analyzing each one for several fission products, the following results were obtained: (1) An approximate half-life of 33 seconds for Kr^{90}; (2) an accurate half life of 1.7 seconds for Xe^{140}; and (3) the fraction of each of the fission-product chains containing a gaseous member that was swept out of the water boiler. (Tables VI and VII). Schematic diagrams and tables are included.

PB 52433, LAVATELLI, L. S., Snouting and focusing the cyclotron beam. (Manhattan Engineer District LADC Rept 128; MDDC Rept 350) Feb 1946. 22 p. Price: Microfilm—$1.00—Photostat—$2.00

Scientific paper released for general information September 26, 1946. The steps necessary to get an external beam down a snout section and the equations for focusing a beam magnetically are given. These equations together with the initial beam configurations and other constraints are solved simultaneously approximately to yield suitable design for a focusing chamber. The chamber enabled a beam of about three microamperes to be focused on an area of one square inch at a point 20 feet distant from the target chamber of the cyclotron. Diagrams and photographs are included.

PB 42178, NIER, A. O. and others, Mass spectrometer for leak detection (MDDC Rept 5) Apr 1946. 18 p. Price: Microfilm—$1.00—Photostat—$2.00

A simple low resolution mass spectrometer is described which has ben used successfully in detecting small leaks in high vacuum equipment. One part of He in 200,000 parts of air can be detected. Photographs, diagrams, and graphs are appended. This contribution from the Kellex Corporation is released through the Manhattan Engineer District for presentation before the American Physical Society.

PB 49579, WATTS, R. J., Safety circuit with D-C amplifier. (Manhattan Engineer District LAMS Rept 161, Series B; MDDC Rept 316) Nov 1944. 15 p. Price: Microfilm—$1.00—Photostat—$1.00

Scientific paper released for general information September 11, 1946. A method is described to record the rise in intensity of any hard beta, gamma, or neutron radiation and cut it off at any predetermined level. A range in intensity of a factor of one million may be covered easily. The equipment is designed so that if any part fails it will fail safely, i.e., in such a manner as to cut off the radiation. The electronic circuits are readily adaptable to many uses and have been used to monitor a cyclotron. Any current of 10^{-11} amperes or higher from a high-impedance source will operate the mechanism. Drawings and circuit diagrams are appended.

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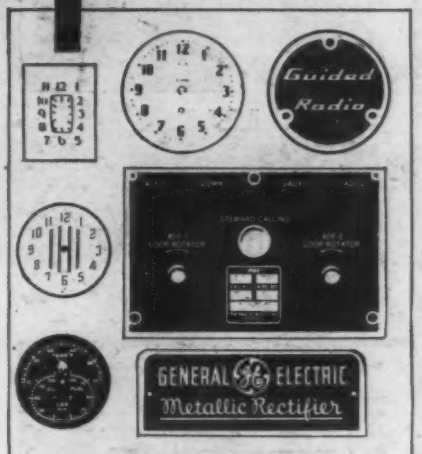

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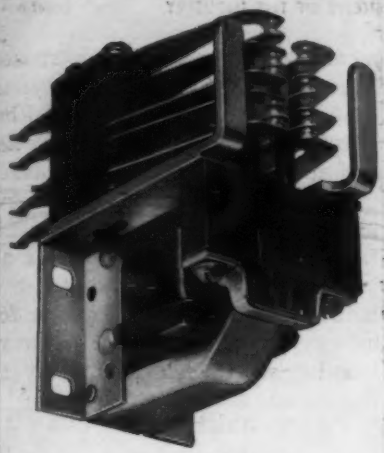

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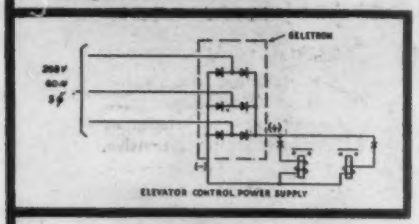

cut control-unit space in half for United Elevator Service.

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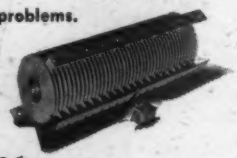

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Radar on Airliners

Incorporation of modern radar in eight Stratocruiser luxury airliners being built for American Overseas Airlines by Boeing is claimed to be the first case of preplanned radar installation in commercial aviation. The ships are to be placed in transatlantic service late this year.

Two antennas will be utilized, one in the nose pointing forward to detect storm areas and areas of dangerous icing, and the other a 60-inch diameter unit in the belly to map shorelines from many miles out to sea and to utilize ground radar beacons along the route for navigation. Such beacons at each end of airport runways will also serve with radar on the planes to simplify blind landings and reduce possibilities of collision with high objects in the vicinity of airports.

Ionospheric Research

Radio propagation conditions in the 28-mc band are being investigated by the Central Radio Propagation Laboratory of the National Bureau of Standards with the voluntary participation of 130 radio amateurs located around the globe. It is hoped that the project will make possible surer recognition of the unusual transmission and reception conditions accompanying sporadic E-layer ionization, which makes communication between two points possible at a higher frequency than the predicted maximum.

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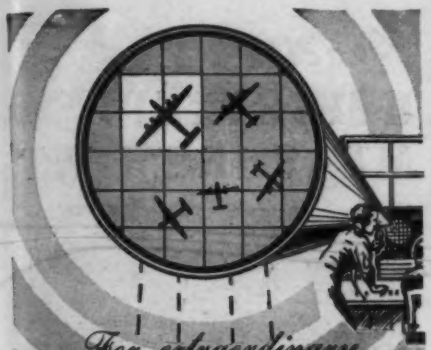

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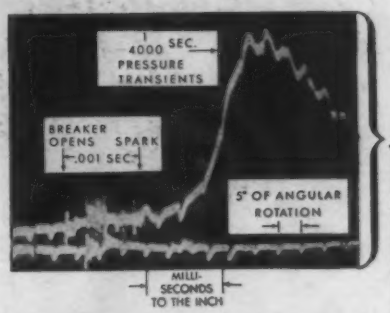

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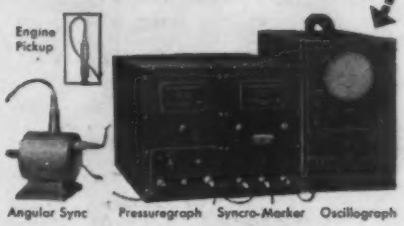

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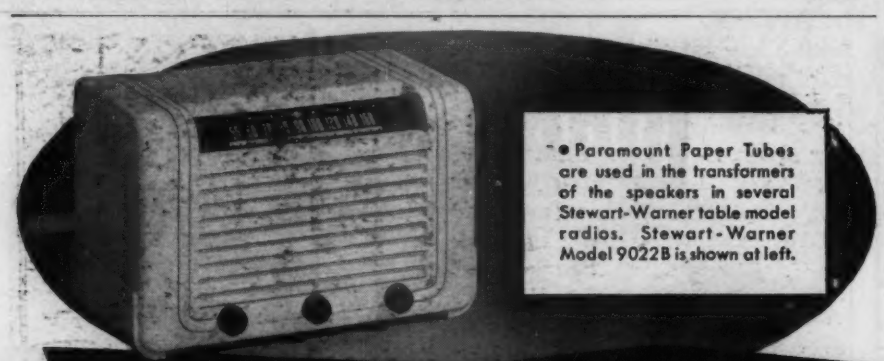

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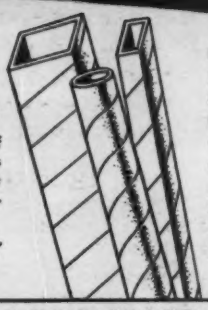

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medical, and scientific purposes. Stipulations provide that emissions shall be confined to the channel between 2,400 and 2,500 megacycles and no interference shall be caused to authorized communication services from spurious or harmonic radiations. Chief uses for this allocation at present are diathermy, induction and dielectric heating for industrial purposes, and microwave heating with such equipment as Raytheon's radarange.

Clearing Low F-M Band

In order to clear the 42-44 mc portion of the low f-m band for use by the nongovernment fixed and mobile services to which these frequencies have been allocated, the FCC has made temporary new assignments above 44 mc for the nine f-m stations that were operating below this frequency. The changes in frequency must be made no later than Feb. 1, 1947. Some affected stations plan to cease operation until their equipment is ready for operation on their regular assignment in the new higher-frequency band.

No date has been fixed by the FCC as yet for transfering of all f-m operation to the new 88-108 mc band. Temporary operation of stations in the lower band is contemplated until sufficient f-m receivers for the higher band are available.

F-M Clinic

THE F-M BROADCAST engineering clinic conducted by Radio Engineering Laboratories in Long Island City starting Jan. 20 drew an attendance of over 100 engineers, some from as far as Liberia and Australia, during four days of lectures, demonstrations, and discussions on technical subjects associated with frequency modulation.

Outside speakers included Major E. H. Armstrong, inventor of the f-m system; Paul A. de Mars, of Raymond E. Wilmotte, Inc., consultant; John Bose, Columbia University; C. M. Braum, FCC; Stewart Bailey, of Jansky and Bailey, consultant; C. Russell Cox, of the Andrew Co., engineer; F. M. McIn-

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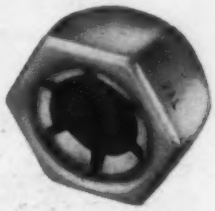

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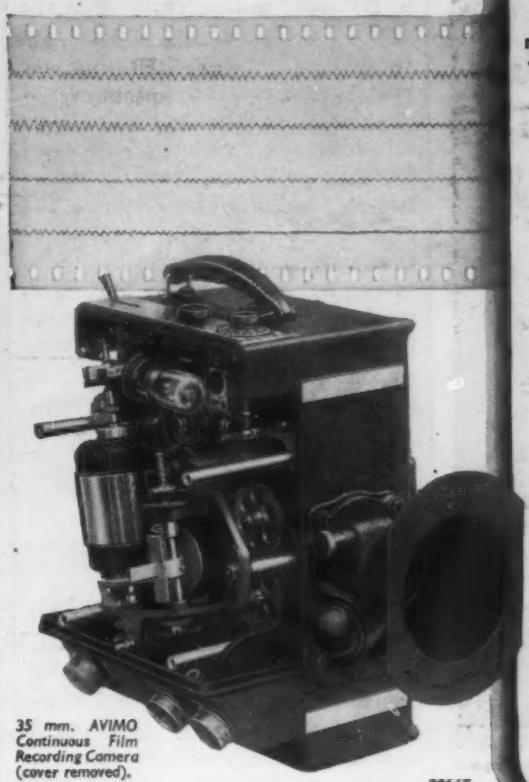

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9016E

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The behaviour of moving parts under actual working conditions may be studied by means of standard commercial oscillographs, which translate mechanical or electrical variations into evanescent traces on a fluorescent screen. Avimo cameras record these traces on continuous film or paper, so that they may be subsequently checked, examined, and measured. Write for Publication C3, giving full details of AVIMO Cameras including types with built-in cathode ray tubes.

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Sensational New Sweeping Oscillator!!

Displays Pass Band
Continuous frequency coverage up through the color television bands

The MEGA-SWEEP

The most versatile high frequency oscillator.

These Amazing Features are Found in the MEGA-SWEEP:

- Frequency Range—50 kilocycles to 500 megacycles!
- Sweep Frequency—Up to 40 megacycles!
- Frequency Meter—Measures from 3 to 800 megacycles!
- Continuously Adjustable Attenuator—Band width 1000 megacycles!
- Output—Approximately 0.1 volt at 50 ohms.

The MEGA-SWEEP shows at a glance the response of any network or amplifier. This eliminates the tedious point to point analysis. Its use saves engineering time and stimulates research. Valuable for television production alignment.

The MEGA-SWEEP is priced for wide use in laboratory and production line. $350.00 FOB East Orange.

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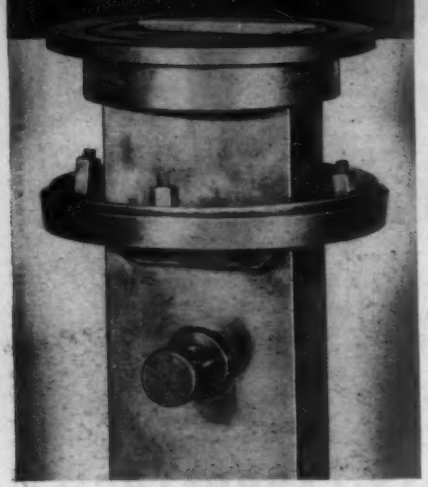
Mfrs. of The MICRO-PULSER, The TOUCH-TIMER, Micro-Wave components and High-Frequency Wavemeters, and other specialized electronic instruments.

RADAR PLUMBING
fabricated fast and economically with
EASY-FLO



The example illustrated is completely fabricated with the low-temperature silver brazing alloy EASY-FLO — the fast-acting, exceptionally free-flowing alloy that makes joints stronger than the metals joined, with the ductility to take all the vibration, shock and temperature changes the metals themselves can stand. It is especially suited for electronic work because of the high electrical conductivity and strong corrosion resistance of the joints and because the low-working temperature is a safeguard against heat damage to light gauge metals. *BULLETIN 12-A* gives full facts. Write for a copy and ask also for details of the new EASY-FLO 45.

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tosh, consultant. Frank Gunther, M. H. Jennings, James Day, and Wilbur Thorp of the REL engineering staff discussed aspects of specific equipment design and use in the field.

During the discussion periods various station operators' problems were presented and the answers volunteered by attending engineers. Mr. Braum, the FCC representative, interpreted regulations and explained the Commission attitude in the absence of specific rulings.

A feature of the demonstration period each day was reception of a special program of live talent broadcast from Major Armstrong's Alpine, N. J. radio station W2XMN. The entertainment originated at the home of Mr. C. R. Runyon, radio pioneer, in Yonkers, N. Y., and was beamed from his high-frequency experimental station to Alpine where it was picked up and rebroadcast.

F-M Polarization

THE FEDERAL Communications Commission has announced that licensees of f-m stations may add circular or elliptical polarization. (ELECTRONICS, p 214, December 1946). Horizontal polarization is still retained as the standard and must be used by all f-m licensees (including those who exercise the option of utilizing circular or elliptical polarization).

Additional transmitter operating power would be authorized to stations employing the new type polarization, but it may not exceed the horizontally polarized component used for allocation purposes; service contours thus remain unchanged.

It is expected that circular or elliptical polarization will decrease the antenna requirements for home and car radio receivers and materially increase the probability that a receiving antenna located at random will provide entirely satisfactory f-m reception.

Taxicab Radio Survey

NEARLY 8,000 taxicabs in the United States, in over 200 different fleets, received FCC authorization for two-

Precise
RESISTANCE MEASUREMENT

. . . *with the Rubicon*
WHEATSTONE BRIDGE No. 1080

A high precision instrument well suited for use as a laboratory standard as well as for routine measurements requiring exceptionally high accuracy.

- Wide range — 1 ohm, readable to within 0.0001 ohm, to 100 megohms.
- Five-dial rheostat usable as separate decade resistance box, 9x(1000+100+10+1)+10x.1 ohms. Limit of error in resistors of 1 or more ohms 0.02%.
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- Heavy substantial aged manganin resistors for high stability.
- Extra-heavy sturdy switches with contact resistance less than 0.001 ohm.

Fully described in Bulletin 100.

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Another of the eighteen bridges listed in Bulletin 100 for nearly every type of resistance measurement . . . from high precision laboratory work to high speed production line inspection jobs. Write for your copy of the new edition of Bulletin 100 today.

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Electrical Instrument Makers
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way radiotelephone units as of the first of the year, and applications for some 2,000 additional units are now being processed. Largest grant of this nature was to a fleet of 1,600 cabs operating in San Francisco and Los Angeles. For the entire mobile two-way radiotelephone service, the total number of experimental authorizations is approximately 1,000, involving some 12,000 taxicabs, trucks, private cars, and other vehicles not in such organized services as police, fire, aviation, marine, railroad, public utility, and geophysical.

Broadcast Engineering Conference in Atlanta

A RADIO broadcast engineering institute will be held in Atlanta, Georgia, April 14-18, 1947 under sponsorship of the Georgia Association of Broadcasters, the Georgia chapter of IRE, and the Georgia School of Technology. Professor Martial A. Honnell of Georgia Tech is general chairman. Outstanding experts in the various fields of radio broadcasting will cover the latest technical developments in their respective specialties, and manufacturers will exhibit and demonstrate latest types of radio and television equipment.

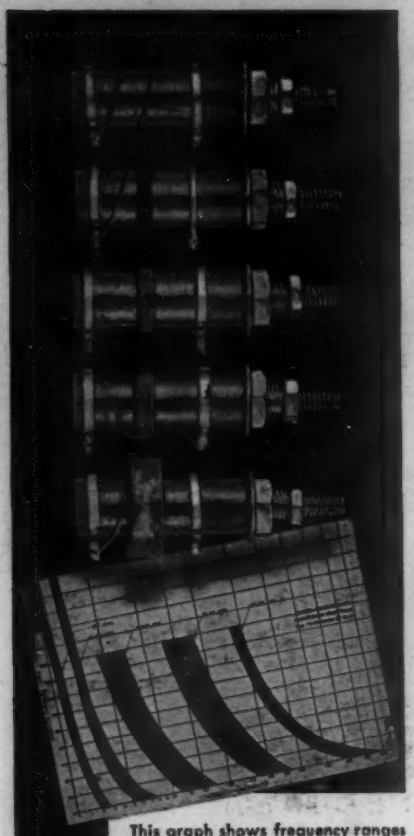
Those attending will also have an opportunity to visit the five radio stations in Atlanta, as well as the modern f-m transmitter now operating on an experimental basis at Georgia Tech. The Institute will be patterned after the Ohio State University national conference, which is not being held this year.

MEETINGS TO COME

MARCH 3-6: IRE Winter Meeting, Hotel Commodore, New York City, with Radio Engineering Show at Grand Central Palace.

MARCH 3-7: 1947 Winter Conference of National Electrical Manufacturers Association, at the Edgewater Beach Hotel, Chicago. Committee meetings only.

MARCH 22-27: Western Metal Con-



This graph shows frequency ranges covered by each unit. Write us for your full-size copy.

Five Standard Slug-Tuned LS3 Coils Cover ½ to 184 mc

For strip amplifier work, the compact (1¼" high when mounted) LS3 Coil is ideal. Also for Filters, Oscillators, Wave-Traps or any purpose where an adjustable inductance is desired.

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CTC LS3 Coils are easy to assemble, one ¼" hole is all you need. Each unit is durably varnished and supplied with required mounting hardware.

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CTC will custom-engineer and produce coils of almost any size and style of winding... to the most particular manufacturer's specifications.

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"Coprox" rectifiers may be your answer to more efficient current control. Their varistor characteristics make them ideal for automatic current valving, current limiting, current blocking, as well as current measurement.

Bradley rectifiers are designed to give you trouble-free service. Their electrical characteristics remain stable indefinitely When operated within normal rating, their life is unlimited.

Send for curves showing current, voltage, resistance and temperature characteristics of Bradley copper oxide rectifiers.

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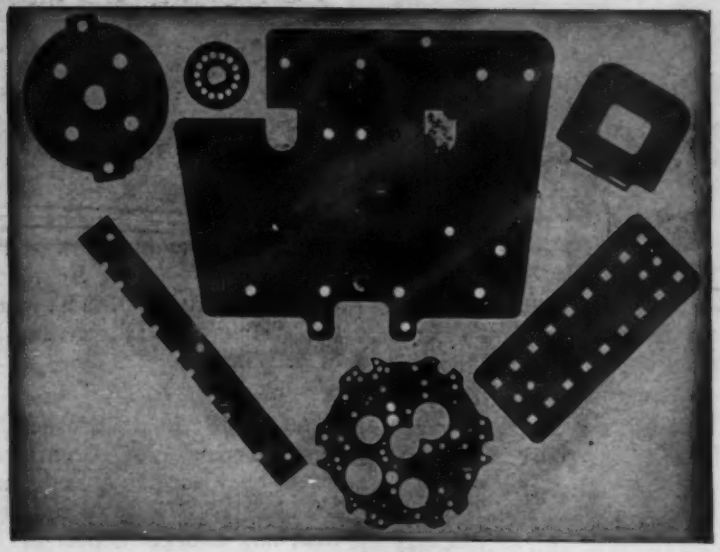

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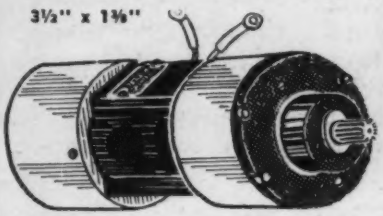
3½" x 1⅜"



Operates on Flashlight batteries, speed depending on the voltage. Fairly strong on 6 volts, full power and speed on 27 volts. Designed to be used in bombsights, automatic pilots, etc. Two types, 145 or 250 RPM. Either speed a bargain at..... **$5.00**

BASIC MOTOR 2 X 1 X 1

ELECTRICALLY SAME AS GEARED MOTOR **$3.00**

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RADIO CORPORATION of AMERICA
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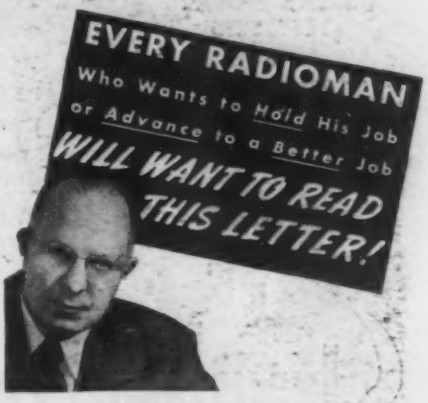
E. H. Rietzke, *President* of CREI, invites You to Write for this

Free

Significant Analysis of Job Opportunities in Radio Electronics.



The Story Behind This Interesting Letter You Will Want to Read . . .

Our advertising agents, realizing that vital changes are taking place in the radio industry, asked me to give them a factual report of the unprecedented job opportunities created by the almost unbelievable expansion of the radio industry.

My letter to them contains some pertinent viewpoints on the subjects of COMPETITION—INDUSTRY EXPANSION—OPPORTUNITIES. These are first-hand observations based on my own experiences . . . a great deal of time spent in the field and constant contact with leaders in the radio industry.

The immediate reaction of our agency upon reading this letter was that it contained so much inspiration and information that it should be reproduced for thousands of radiomen to read. Therefore, this unusual advertisement to invite you to send for, and read, this letter.

It is doubtful if many radiomen realize the actual things that are happening. That is why I think you will want to read this letter. You are invited to send for your personal copy today.

E. H. Rietzke
President, CREI

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Capitol Radio Engineering Institute 16th and Park Road, N. W., Dept. E-3 Washington 10, D. C.

Gentlemen: Please send me FREE, Mr. E. H. Rietzke's Analysis of Job Opportunities in Radio-Electronics.

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INCREMENTAL INDUCTANCE BRIDGES

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QUALITY-TESTED PRODUCTS FOR THE ELECTRONIC INDUSTRY

MODEL 204A — REGULATED POWER SUPPLY
0-500 Volts D.C. at 300 Ma. with Positive or Negative Ground
The Model 204A Regulated Power Supply will provide from 0-500 volts of well regulated and well filtered D.C. The output voltage is continuously variable without switching and either positive or negative side may be grounded.

Specifications:

OUTPUT VOLTAGE
High Voltage: 0-500 Volts D.C. continuously variable (Without switching). Current: 300 Ma.
Low A.C. Voltage: 6.3 Volts A.C. at 6 amps. center-tapped, unregulated.

REGULATION
Within 1% for voltage between 30-500 volts, from no load to full load.
Within 1% for line voltage variations from 105 to 125 volts at full load current for any voltage between 30-500 volts and within 2% at 10 volts.

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Within 10 Millivolts at any voltage or load with ratings.

LINE INPUT
105-125 Volts A.C. 50-60 cycles.

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High and low voltage outputs available from front and rear of unit. Positive or negative terminal of high voltage output may be grounded as desired.

Detailed specifications will be forwarded upon request.

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gress and Exposition, Oakland Civic Auditorium, Oakland, California; over 75 technical papers, lecture courses, and round table discussions.

MARCH 31-APRIL 2: Midwest Power Conference, Palmer House, Chicago, sponsored by Illinois Institute of Technology and directed by Prof. S. E. Winston.

APRIL 14-18: Radio Broadcast Engineering Institute, Atlanta, sponsored by Georgia Association of Broadcasters, Georgia chapter of IRE, and Georgia School of Technology, with Professor M. A. Honnell of Georgia Tech as chairman.

APRIL 21-MAY 2: International Merchant Marine Radio Aids to Navigation; first week devoted to exhibits, papers, and visits to firms in New York City and vicinity; second week on three ships working out of New London, Conn. for demonstrations of equipment; sponsored by U. S. State Department and other government agencies.

APRIL 28-30: RMA Spring Meeting of transmitter and transmitting tube engineers, at Hotel Syracuse, Syracuse, N. Y. Technical sessions and meetings on first two days, with inspection trips on third day.

MAY 17: New England Radio Engineering Meeting of North Atlantic Region of IRE; six technical sessions, luncheon, and banquet at Continental Hotel, Cambridge, Mass.

MAY 4-8: National Electrical Wholesalers Association meeting, Traymore Hotel, Atlantic City, N. J.

MAY 13-16: 1947 Conference and Show by Radio Parts and Electronics Equipment Shows, Inc., Chicago.

BUSINESS NEWS

TELEVISION BROADCASTERS ASSOCIATION, INC., New York City, announces reelection of J. R. Poppele as president for a third term. Two new directors, John F. Royal of

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- SILVER-SOLDERED TERMINALS
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The TRU-OHM Resistor is a superior product of fine engineering skill and manufactured with war-tested experience. A wide variety of types is available for immediate or quick delivery. Write us your requirements or send for free catalog.

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For Every Requirement

ROGAN offers a large selection of plastic Knobs from stock molds. These are supplied without tool charge. Available in various sizes, shapes and colors. Smartly styled, quality made, ideally suited for a wide range of applications. Markings can be branded in "deep relief" on blank parts, as desired. Whatever your knob requirements may be, Rogan is equipped to serve you faster, better, more economically. In addition, Rogan offers a complete source of compression molded parts of all types. Write for complete details NOW!

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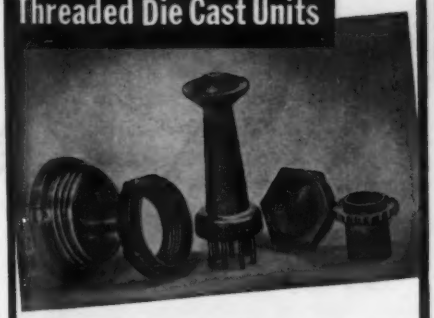

Intricate parts of 100% rust-proof Zinc alloy.
Accurate to specification Held to tolerances of .005.
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Ideal for instrument, small machine and minute electronic parts.

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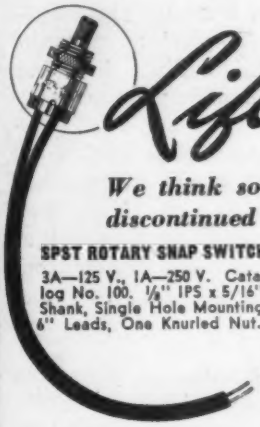

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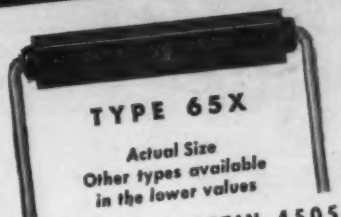
The "All-Weather" Resistors



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STANDARD RANGE
1000 ohms to 10 megohms
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At slight additional cost, resistors in the Standard Range are supplied with each resistor noise tested to the following standard: "For the complete audio frequency range, resistor shall have less noise than corresponds to a change of resistance of 1 part in 1,000,000."

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Console $90 Chassis $295
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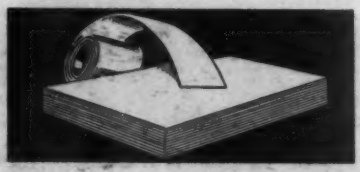

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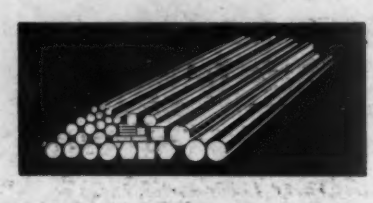

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NBC and Frank P. Schreiber of station WGN, were elected to the Board, replacing O. B. Hanson of NBC and E. A. Hayes of Hughes Tool Co.

THE WARD PRODUCTS CORP., Cleveland, Ohio, has been purchased by The Gabriel Co. of Cleveland, and will continue operation as a division of the latter company.

DUNLEE CORPORATION, Chicago, Ill. has been organized for the design and manufacture of x-ray tubes, with H. A. Dodge as president, D. W. Dunk, formerly with Eureka X-Ray Tube Corp., as vice-president of manufacturing, and Z. J. Atlee, formerly with General Electric X-Ray Corp., as vice-president of engineering.

WESTINGHOUSE ELECTRIC CORP. announces a broad sales and servicing agreement with Tropical Radio Service Corp., wholly-owned subsidiary of United Fruit Co. Westinghouse will manufacture complete marine radar equipment of its own design, of the continuous ppi type with range of from 100 yards to 32 miles, with Tropical as a major channel for installing, licensing, servicing, and selling the units.

MUTUAL BROADCASTING SYSTEM has begun work on $2,500,000 radio and television studios in Hollywood, Calif., in which is to be a unique quarter-million-dollar master control panel serving a-m, f-m, and television.

GENERAL ELECTRIC CO., Syracuse, N. Y., shipped its 100th f-m radio broadcast transmitter to station WPEN-FM in Philadelphia, and is now working to fill the more than 100 additional orders still on hand.

EASTERN AMPLIFIER CORP., New York City, announces assumption of complete control by Leon Alpert. The new management plans to expand the products and sales of the firm in the sound systems field.

HAZELTINE ELECTRONICS CORP., New York City, announces that starting March 1 its Lanac system will be in every day operation by the AAF All-Weather Flying Division on the air route between Clinton County

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- Communications
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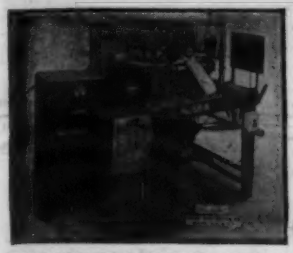

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For LIGHTING FURNACES POWER PHASE CHANGING DISTRIBUTION ETC.

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Air, Oil, or Water Cooled

Sizes ¼ To 250 KVA

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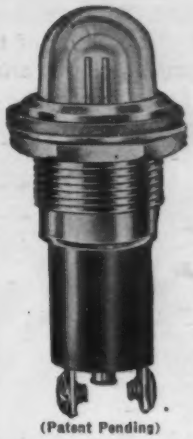

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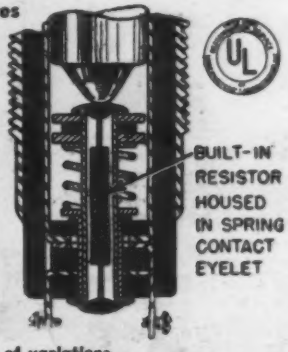

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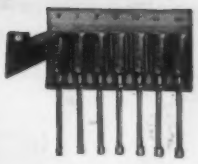

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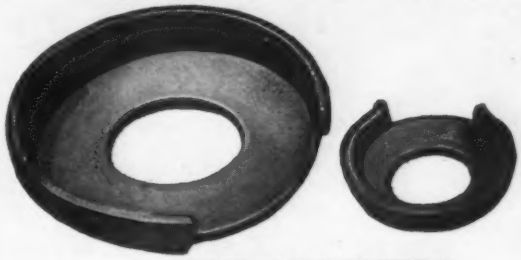

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CAP SCREWS

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(7) Speed in assembly provided for by use of Allen hand drivers and key blades for power drivers.

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Army Airfield and Andrews Field in Maryland. In earlier tests of the system at Indianapolis, three Lanac-equipped planes were able to land at one-minute intervals through an overcast so bad that all commercial planes in the area were grounded.

BLACKBURN-HAMILTON Co. has been organized as a firm of radio station brokers, with offices in Washington, D. C. and San Francisco, Calif.

BURNDY ENGINEERING Co. has opened a new factory and warehouse in Vernon, Calif., for manufacture of connectors.

New Burndy plant in California

ALLEN B. DU MONT LABORATORIES, INC. has installed a new RCA three-bay superturnstile antenna for its television station WABD in New York City, increasing the effective radiated power from 1.81 kw to 17.8 kw, which gives the maximum coverage allowed by present FCC regulations.

HALLICRAFTERS Co., Chicago, is sponsoring a six-month expedition to equatorial Africa for exploration of the Mountains of the Moon and the Lost Lakes of the Ruwenzori and to conduct scientific research and short-wave radio experiments. Leader is Commander Attilio Gatti. From the expedition's field camp on Ruwenzori, a powerful short-wave radio station will maintain contact with the home station at the new Hallicrafters plant in Chicago, and with amateur radio operators throughout the world.

BENDIX RADIO DIVISION, Baltimore, Md. announces that one of its latest radar airport surveillance devices, known as AN/GPN-2, has been loaned to CAA by the U. S. Navy for use at Pittsburgh airport to provide exhaustive practical testing of radar for airport traffic control. It gives 360-degree coverage up to 10,000 feet altitude within 30 nautical miles of the airport. De-

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Any requirements in a cathode ray tube connector with proper leads attached engineered as an assembly, high safety factors in all kinds of service. Super-long leakage paths rounded, "coronaless" clips and individual pocket type insulation and strain relief.

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Shielded plug and socket for automobile sets or for any other equipment where leads must be shielded and shield grounded to chassis. Shield is easy to put on and solder to plug. Supplied with or without shielded cable.

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Famous for connecting AC motors in combination sets and all kinds of "through-panel" work. Overall diameter only ¾". Save labor costs by having our special wire equipment put on leads to your particular needs. Underwriters approved.

121-5 MINIATURE PLUGS AND 441-5 SOCKETS

Compact plug and metal seal socket. Use when you want connector to come directly out of chassis. Leads to your specifications. "Pocket" type individual insulation on each lead and clip.

AC OUTLET 402AC

Smallest possible outlet that can be eyeletted or riveted to chassis like other components. Tabs designed for easy soldering.

AC LINE CORDS 202 SERIES

Detachable AC line and with socket, neat and compact. Socket eyelets or rivets in place like other components. Underwriters approved.

FUSEHOLDER 440FH

Here is a fuseholder that rivets or eyelets in place like the other components in your set. Cannot twist or turn, has spring to eject fuse if it breaks, and make contact at base of fuse and prevent rattle. Top contact slotted for easy removal of fuse ferrule when glass breaks. Tabs are special design for ease in attaching primary leads of ample size.

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Any requirement in tube cap connectors supplied with leads of proper voltage handling characteristics. Many made special, hundreds of moldings, stampings and wire to draw on.

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Supplied with tailor-made leads. With or without escutcheon and bracket. Individual insulation and strain relief for each lead.

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Replaces terminal strips. Supplied with leads. Each lead has individual insulation and strain relief.

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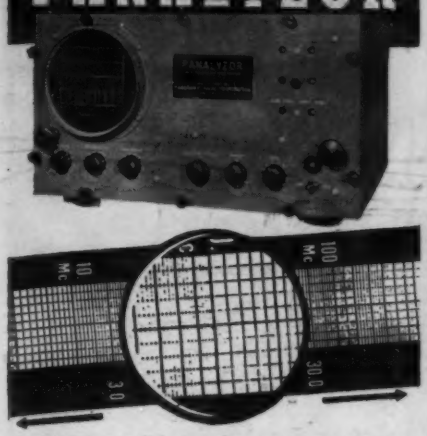

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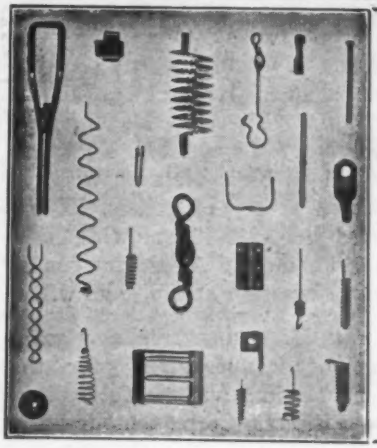

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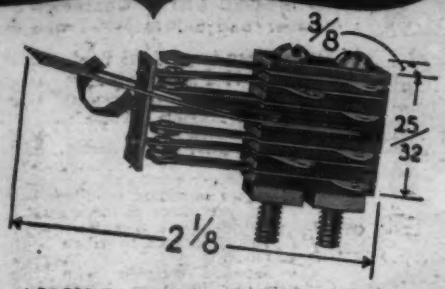

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Ideal for Audio, Supersonics, Lower Radio Frequency Spectrum. Measures Stage Gain, RF and IF Amplifiers on Broadcast Receivers.

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signed as a mobile supplement to GCA, the equipment requires only one operator and includes two-way radio operable on all aircraft frequencies. Fast time constant circuits reduce the masking effect of ground clutter on the ppi indicator, simplifying tracking of planes close to the ground.

PACIFIC ELECTRONICS ENGINEERING CORP., Los Angeles, Calif., is setting up a demonstration microwave transmission service between Shanghai and Soochow in China as the first step in selling microwave equipment to the Ministry of Communications for eight-channel telephone communication service to serve in place of wire lines. Advantages of radio include freedom from pilferage of wire.

PERSONNEL

WILLIAM F. COTTER becomes chief engineer for Scott Radio Laboratories, Inc., Chicago, succeeding Marvin Hobbs who is engaging in consulting engineering on radio broadcast equipment.

EUGENE FREKKO was appointed chief engineer of the electrolytic division of Cornell-Dubilier Electric Corp., South Plainfield, N. J., succeeding Paul McKnight Deeley who becomes manager of the plant.

JOHN I. ADAMS is director of research for Schweitzer Paper Co., Mt. Holly Springs, Pa. in connection with manufacture of capacitor papers. He was formerly with the paper group at the Pittsfield, Mass. plant of General Electric Co.

CONRAD H. HOEPPNER has resigned as head of the Naval Research Laboratory Telemetry Group to become director of the Glenn L. Martin Co. Electronics Laboratory, Baltimore, Md.

EMIL REISMAN, formerly with International Resistance Co. for over 14 years, is chief engineer of Resistance Products Co., Harrisburg, Pa.

EVERETT W. THATCHER becomes head of the research division of the

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Low-Priced
Type CR-7
CRYSTAL HOLDERS

In manufacturing millions of crystal holders during the war, Colonial developed methods which enable them to mass-produce Type CR-7 ceramic base crystal holders at an *unbelievably low cost.*

To you as a crystal or radio manufacturer, this low holder cost means that you can market a lower priced crystal — or that you can apply crystal control to many additional electronic applications in which high cost has prohibited widest possible crystal use.

Check the specifications of these Type CR-7 crystal holders, then write for a quotation on whatever quantity will fill your needs.

Colonial Type CR-7
Ceramic Base Crystal Holders
Specifications:
Base dimensions—5/16" x ¾"
Cover Height—½" or ¾"
Leads—tinned copper wires 1¾" long
Mounting springs—any height
Sealing—mechanical—adequate protection for all average conditions

COLONIAL ELECTRIC PRODUCTS
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Cold Cathode Fluorescent Lamps
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Colonial Electric
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Naval Electronics Laboratory at Point Loma, California. He served as deputy technical director of the atomic bomb tests at Bikini, and during the war studied enemy electronics activity in France and Germany.

VANNEVAR BUSH, president of Carnegie Institution of Washington and wartime director of OSRD, has been named the 1946 winner of the Hoover Medal, jointly awarded by AIEE, ASCE, AIMME, and ASME. The citation reads, "Engineer, educator, and administrator, who, in critical time of need, was in a most special sense an organizer, guiding spirit, and driving force of the nation's achievements in physical and medical science; to whom, for outstanding public service, is awarded the Hoover Medal for 1946."

KENNETH A. NORTON becomes chief of the recently established Frequency Utilization Research Section of the Central Radio Propagation Laboratory at the National Bureau of Standards. This section will investigate the utility, for specific applications, of various portions of the crowded radio spectrum. Currently the section is studying comparative accuracy of various existing and proposed radio navigation systems for aircraft and ships.

K. A. Norton

G. C. Kuczynski

GEORGE C. KUCZYNSKI has been appointed to the research staff of the Sylvania Electric Metallurgical Laboratory, Bayside, N. Y., where he will do basic research work on electron theory of metals. He received the 1945-46 Baldwin-Southwark Fellowship Award for fundamental work on strain gage wires.

FRANK H. BARNETT is now manager of manufacturing for the Home Radio Division of Westinghouse Electric Corp., Sunbury, Pa.

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SUPREME Oscillators cannot measure the wave length of your dollars, but they can increase the frequency by which they find themselves stopping in your cash register.

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NEW BOOKS

Industrial Carbon

By C. L. MANTELL. *D. Van Nostrand Co., Inc., New York, N. Y.*, 1946, *Second Edition*, 472 *pages*, $7.50.

IN ACHIEVING thorough coverage of applications of carbon aside from its use as fuel, this book devotes one 12-page chapter to the subject of electronic tube anodes. This chapter, prepared by H. W. Abbott, Director of Laboratories for Speer Carbon Co., presents a comparison of the characteristics of graphite, molybdenum and tantalum, the three materials most used as anodes of power tubes, then covers in detail the characteristics and manufacturing techniques employed in making carbon anodes for tubes.—J.M.

Radio Operating Questions and Answers

By ARTHUR R. NILSON AND J. L. HORNUNG. *McGraw-Hill Book Co., Inc., New York*, 1946, *Eighth Edition*, 434 *pages*, $3.50.

THE LATEST edition of this standard technical radio review book contains some revisions to compensate for slight changes in FCC license examinations during the past four years, along with some new questions. All answers to questions are in essay form to facilitate the study required for answering multiple-choice examinations now in use. The one outstanding new feature is the adoption of ASA symbols for circuit diagrams. All diagrams have been revised to conform to the new standards and an appendix presents a complete compilation of these symbols.—J.M.

Electrical Engineering

By FRED H. PUMPHREY. *Prentice-Hall, Inc., New York, N. Y.*, 1946, 369 *pages*, $5.35.

THIS BOOK, intended as a text in electrical engineering for students specializing in other fields, handles the problem of holding interest by restricting early chapters to essential theory and by devoting almost half the number of pages to electronic topics and applications. The author points out in the foreword that amplifiers as applied to gages and oscillators as applied to high-

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. . . DAYLIGHT QUALITY

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PHOTO-FLASH TUBE
Model FF-1

Manufacturers or users of electronic photo-flash equipment seeking the best tube for initial installation or replacement, should investigate Colonial's new Xenon-filled FF-1 tube which produces a flash of daylight quality—*and permits the use of daylight color film at all times.*

Designed to deliver highest lumen output for each watt-second of energy consumed, the FF-1 — used with a 30 MFD condenser charged to 2500 volts—*has a light output greater than the "Press-40"* at a shutter speed of 1/400th. Its gas-discharge flash reaches a value of approximately *20 million peak lumens* in a total time of 300 micro seconds—and the tube has a life *in excess of 20,000 flashes.*

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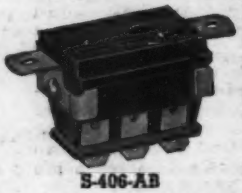

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frequency generators are becoming equally as important to civil and mechanical engineers as to electrical engineers. The book is interestingly illustrated and many of the exercises are so arranged that instructors can substitute values of their own to increase the variety of numerical examples available.

Industrial electronic topics covered include induction heating, electrostatic precipitation equipment, rectifiers for electrochemical processes, electronic motor control, fluorescent lighting, industrial measurements and automatic control, electronic timers, and photoelectric controls. The final chapter deals with electrical communication. This book is part of the Prentice-Hall Electrical Engineering Series, of which W. L. Everitt is editor.—J.M.

Plastics Handbook for Product Engineers

By JOHN SASSO, *former Managing Editor of Product Engineering. McGraw-Hill Book Co., Inc., New York*, 1946, 468 *pages*, $6.00.

PHYSICAL and chemical properties of plastics and synthetic rubber are presented in concise form for the product engineer and other users of plastics. Electrical insulation, dielectric stress, flow temperature, and other characteristics of importance to electronic engineers are included. Factors governing failure of plastic products as insulators in electronic equipment receive detailed attention. The use of electrostatic heating as a method of working plastics is presented in the chapter on recent developments and techniques.—F.R.

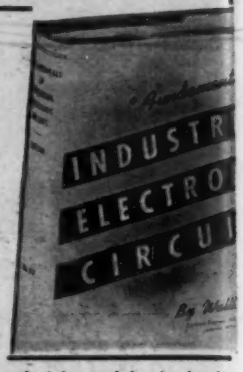
The Decibel Notation

By V. V. L. RAO. *Chemical Publishing Co., Inc., New York*, 1946, 179 *pages*, $3.75.

THE CONTENT of this printing is the same as that published elsewhere (ELECTRONICS, p 406 Dec 1945). The treatment includes not only elaborate discussions of the decibel, neper, and phon, but also developments of transmission characteristics in acoustic and electric systems, manipulations of logarithms, and characteristics of sound transducers. Much space is devoted to obsolete terms and values.—F.R.

Explaining the performance of ELECTRON TUBES in fundamental combinations

Pointing the way to the design, analysis and maintenance of electronic circuits



This book provides both engineers and practical plant men with a clear understanding of the performance of electronic tubes in fundamental combinations with other circuit elements. It demonstrates the basic principles applying to circuits containing vacuum tubes, reducing such circuits to a combination of more familiar circuit elements. The material covers a broad range, from fundamentals of direct current, to auxiliary circuits and equipment for cathode-ray oscilloscopes. Included are such recent combinations as resistance capacitance tuned oscillators, phase-shift oscillators, and circuits for photoelectric tubes.

Just published!

Fundamentals of INDUSTRIAL ELECTRONIC CIRCUITS

By WALTHER RICHTER
Consulting Electrical Engineer, Allis-Chalmers Manufacturing Company

569 pages, 6x9, 397 figures, $4.50

Here is an essentially practical and highly useful presentation of electronic circuits, bridging the gap between the popular, and the rigorous, highly mathematical, treatments. The treatment is complete. It provides enough information to enable you to analyze and design such circuits, yet keeps mathematical requirements to a minimum. Stressing fundamental principles, the book covers the elements of electronic circuits in clearcut detail, emphasizing as well the similarity between these and other electric circuits, so that the reader may tie up this new subject with what he already knows.

Here are a few of the topics covered in the 27 chapters in this book:

Nonlinear Conductors
Fundamentals of Rectifier Circuits
Multigrid Tubes
Multistage Amplifiers
Cathode Followers
Vacuum Tube ac Voltmeters
Beat-frequency Oscillators
Multivabrators and Trigger Circuits
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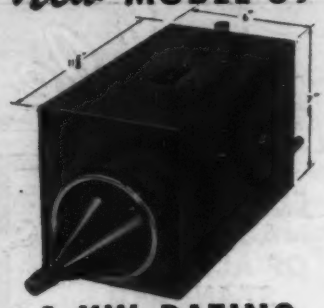

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Backtalk

This department is operated as an open forum where our readers may discuss problems of the electronics industry or comment upon articles which ELECTRONICS has published.

More on Hearing

GENTLEMEN:

It has pleased us a great deal that our article titled "Auditory Perception" in the July 1946 issue of ELECTRONICS aroused so much interest and response. With the exception of the opening paragraph in Mr. Lamport's letter (p 264, January 1947), which in view of later temporizing appears overstated, we found his critical comments interesting. The subject is controversial and will always remain so to the extent that it is related to the enjoyment of music, hence to the widely varying concepts, educational backgrounds and opinions that enter into any evaluation of what is desirable in any form of artistic expression.

Mr. Lamport says that we "do not really accept the human ear as the basic perceptor of sound—but rather regard it as an imperfect instrument for which the good radio engineer should compensate." This is not entirely accurate. The effect known as "scale distortion" occurs when the reproduction is not at the same intensity as the original sound.

Distortion may be defined as any change between the original signal and the reproduction. It is our concept that the final subjective experience of the listener is the criterion of correct design. It is the brain that must be satisfied, not the ear.

Mr. Lamport describes a condition which he believes would result in perfect reproduction, "provided the volume was adjusted to the same intensity. If he turns the volume lower, he will hear a different rendition." Obviously there is complete agreement on the phenomena under consideration. The difference is that we believe compensation for the effect is desirable. Mr. Lamport does not agree. He admits that we may be right but says it is his opinion that we are wrong, and indicates that the burden of proof is on us.

We would like to make it clear that we have no axe to grind in this connection. We have devoted a good portion of twenty years to the study of problems related to music reproduction. We have conducted listening tests with thousands of observers. The principles on which our basic suggestion is developed do not represent an innovation, but merely a method of accomplishing a well known effect automatically. It is our experience that most competent and critical observers prefer a slightly rising bass and treble characteristic for music reproduction at low intensity levels. If as a result of extensive personal listening under controlled conditions Mr. Lamport doesn't like this, we have no quarrel with his individual taste.

At the end of his letter he says, "the better the receiver, the louder it can be played with enjoyment until, I expect, the same intensity as the original sound will be the customary one and the problem considered by Goodell and Michel will have disappeared." The first half of this statement is entirely correct. We submit that anyone who operates equipment so as to produce sound intensity comparable to a symphony orchestra in his living room is probably either deaf or trying to break a lease. . . .

. . . we believe no listening tests comparing two reproducing instruments have any validity in determining the desirability of faithful reproduction. The comparison must be made between reproduced and live music . . . The task of the engineer designing reproducing devices should be confined to reproducing for the listener the same subjective experience that he has when observing the original signal.

JOHN D. GOODELL
Chief Engineer
The Minnesota Electronics Corp.
St. Paul, Minnesota

CONSTRUCTION permits have been granted to Winfield Morton by the FCC for temporary provisional f-m radiotelephone links between Santa Fe and Abiquiu, New Mexico, using 250 watts on 39.54 mc. Abiquiu is in an isolated ranch area with 700 population, without telephone contact.

electronics

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APRIL • 1947

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